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Dump Bed Lifting Mechanism

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By

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MET 495
SENIOR PROJECT PROPOSAL

Table of Contents

Table of Figures

Table of Tables

Abstract

The project was motivated by a need to create a device that would cause a small truck or trailer bed to lift up quickly and dump its contents. This would eliminate the need to use manual physical labor, which is both slow and exhausting. Additional design constraints require the stroke and diameter of the cylinder to be 6” x2”. A design was conceived with the intent to incorporate a less costly device onto an existing trailer frame that would lift the bed and dump the load. With this in mind, a scissor lift device would have two basic requirements, first to lift 500 pounds and second to achieve a 40 degree angle of lift. The intended design is called a scissor lift. Lifting mechanisms for dump trucks are too large and expensive for use on a small six foot trailer. Designing a lift to use a smaller cylinder to accomplish the same task as a larger lift, was accomplished with engineering design. This smaller cylinder presents a geometric challenge so there is enough lift to tilt and dump the load. To accomplish this, the lift will have to accommodate the cylinder to transfer its force through the arms. The calculations predicted that a .5 gpm hydraulic pump would take 62 seconds to lift 500 pounds, dump and lower the load. Initial tests indicated a tilt goes to 39 degrees.

INTRODUCTION

Motivation and Scope

This project was motivated by a need to create a device that would cause a small truck or trailer bed to lift up quickly and dump its contents, eliminating the need to use manual physical labor, which is both slow and exhausting. This device will be incorporated into a homemade trailer and be engineered to lift up the surface of the dump bed to an angle sufficient to empty the contents consisting of dirt, rock, grass, wood or similar materials. The intended use for this device would be in a farm or similar setting where a minimal labor force is available. This project is being approached as a single individual, as his MET senior project. The majority of the effort for the individual will be in the design and analysis of the scissor arms. This will be the most critical part of the system. There will also be considerable effort in the machining and assembly necessary in the construction of the device. This project will consist of three areas, design, manufacturing and testing.

Function Statement

The function of the mechanical device is to lift and tilt a dump bed that facilitate the unloading of various materials. Atual

Design Requirements

In order to fulfill the requirements of this project, the device must meet these parameters:

- It must be compact. 26”x16”x12”
- It must tilt a 6-foot bed to a 40º angle.
- It must be able to lift a load with a cylinder with a maximum extension of 6 inches.
- Must lift up to 500 pounds centered on the dump bed, located three feet from the hinge point.
- Must be able to lift the load with an input pressure of 1000 PSI or less.

Engineering Merit

This problem presents several engineering challenges and opportunities for the optimization of the device. The main engineering challenge consists of creating a design that uses a cylinder that achieves the necessary tilt and lift to unload a dump bed, while maintaining a lower cost to produce. Therefore the device will be optimized for cost and size using a smaller cylinder for the lift, because commercially available lifts are expensive and larger than what’s required or needed for this application. This project will also involve areas of shear stress, moment, and hydraulics.

Success Criteria

This project will be successful if the device is able to lift a load of 500 pounds, dump the load, and then return to the starting position.

DESIGN & ANALYSIS

Approach

A design was conceived with the intent to incorporate a less costly device onto an existing trailer frame that causes the corresponding dump bed to lift and dump a load. With this in mind the device has two basic requirements, to lift 500 pounds and to achieve a 40º angle of lift with a smaller, less expensive cylinder with a stroke of 6 inches. The intended design is called scissor lift. The scissor lift will be incorporated onto a frame and be mounted below the dump bed. The scissor lift will have pivot points and a mounting bracket with the dump bed positioned on top of it.

Description

This scissor lift will reside on the trailer frame underneath the dump bed. There are two mounting points for the scissor lift. The scissor lift will be attached where it meets the trailer frame and also where it meets the dump bed. These points will be welded at the correct locations dictated by the scissor lift. The lift will have an upper and lower arm being symmetrical on both sides with a hydraulic cylinder applying the force to the upper arm using the lower arm to help the pivot. This device will have four pivot points that will rotate the scissor arms and cylinder. The placement of the scissor arm would depend on the point where the 40º tilt angle of the dump bed would be achieved. Placement of the device is also a constraint. Placing the device close to the pivot point won't achieve the required lifting force, and placement furthest away from pivot point won't achieve the 40º angle requirement. Alignment will also be an issue, and will be taking into account. Ways to avoid misalignment would be to use C-ring to keep the arms in place and not move. The device will need to be lubricated, for this grease fitting will be installed at the pivot points to decrease friction.

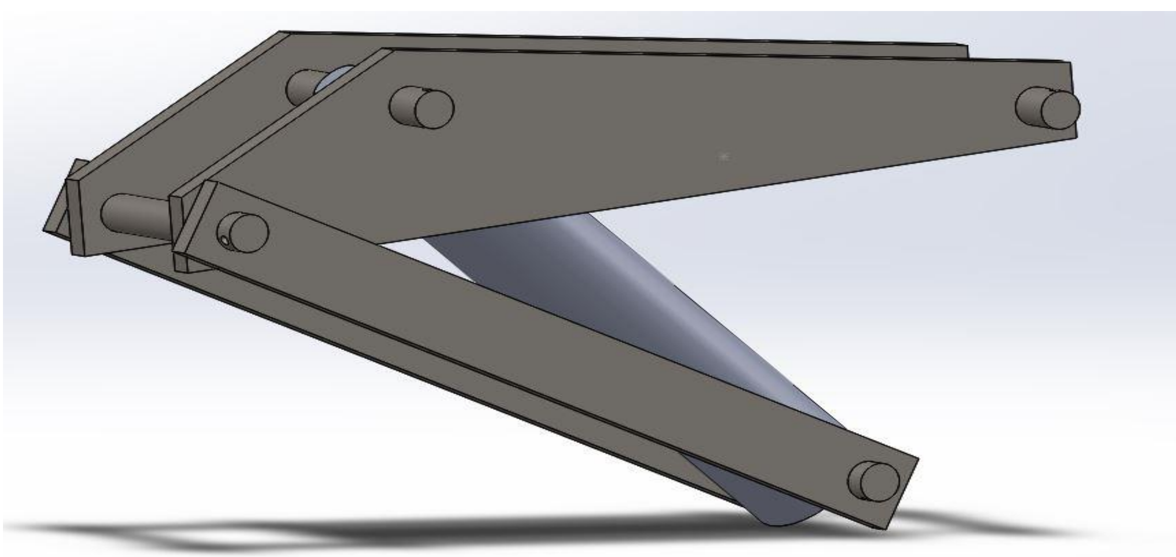


Figure 1 Scissor Lift Design

Benchmark

Figure 2 shows a Venco VC520 conversion hoist for trucks and is an example of what the dump bed that was previously discussed could look like. It is designed for a 9' to 15' frame with capacities of up to 20 tons with a 5" cylinder and 20" stroke. Starting price is over $2,500. In the example the part looks like it has welded members, four pivot points, and the ability to be placed on to a truck or trailer frame.

Figure 2 Benchmark Lift Example

Performance Prediction

The performance will depend on the flow rate of the pump and size of the cylinder. My calculated prediction with a .5 gpm pump is that it will take 62 seconds to lift 500 pound, dump and lower the load. Reference Appendix A, Figure 3 and 4, for performance calculations.

Description of Analyses

The analyses began with determining the load at the initial lifting position of 500 pounds. Reference Appendix A, Figure 5, 6 and 7, for calculations. This is where the lift is in the closed position and has the greatest forces required to lift the bed. After finding the geometry in the closed position and summing the moments to find the load of 700 pound acting on the upper scissor arm for the minimize force of 2758 pounds was necessary to open the device. Then find the necessary pressure that is required by the cylinder exert 2758 pounds. A pressure of 864 psi is required for a two-inch cylinder. Reference Appendix A, Figure 8, for calculations.

Analysis

This section will cover approach, calculated parameters, and tolerances.

- Approach: The Analysis began with the need to calculate the necessary forces required to open the scissor lift burdened by the weight of the dump bed and its contents. Calculating the sum of the moments will accomplish this. After this force was determined, then the forces that are on the upper arm could be evaluated. In this particular project the majority of the analysis focuses on the upper scissor arm, this arm is the most critical and will determine if the load can be lifted.

- Optimization: This device has been optimized to use a cylinder that has a bore size of 2 inches and stroke of 6 inches. Appendix A, Figure 5, shows the force necessary to open the dump bed with the determined geometry. Large cylinders that are commonly comprised of at least a 5 inch bore and a 20 inch stroke are expensive and must be placed into a stronger, larger more costly structure, as in Figure 2. This device is a smaller version that is similar to the previously discussed benchmark. By using a less expensive smaller cylinder, this new device will perform a similar function, in less space and be able to handle smaller loads, making it more manageable and safer.

  Significant cost savings will be realized by using a small cylinder. The small cylinder can be obtained for around $70, while the cost of the large cylinder is over $400. Costs were obtained using information from SurplusCenter.com

- Required Parameters: A minimum force of 2758 pounds is required to lift the load of 700 pounds at 31 inches. Reference Appendix A, Figure 5-7. The 700 pound load consists of 500 lbs. of material, 100 lbs. of the dump frame, and an added 100 lbs. by the moment. 2758 pounds was found by calculating the forces in each arm.

- Calculated Parameters: In Appendix A, Figure 3, shows the estimated time it will take the lift to dump the load with a pump flow of two GPM. It accounts for 45 seconds for the load to be dumped out, and a total time of 49.29 seconds to lift, to dump, and to close. Figure 4 is the same calculation with a pump that has a decreased flow rate of .5 GPM. This should slow the process of lifting and closing and make the lift safer. Figure 8 shows the minimum pressure required to obtain the force of 2758 pounds is 879 psi. Figure 9 is showing the max load for the pin at 2758 pounds. Figure 10-15 is FEA done in SolidWorks showing the von Mises stress, displacement, and what the safety factor is for a load ranging from 2000 lbs. to 4000 lbs. on the upper lifting arm.

- Tolerances: The tolerances for this project will be different for the application. For tolerance on the cut of plate and hole location can be looser, +/- 0.1 hole location. The looser tolerance will help with time and machining cost. For the holes size tolerance will be -0.0 + .05. hole size needs to be more precise for an accurate fit for the pins. Pins need to be the most accurate with a tolerance of +/- .01 inch.

Technical Risk Analysis

This device has a calculated failure mode where the device will not open when it's overloaded. The maximum pressure for the system is 2,000 psi and lift arm will hold the maximum hydraulic cylinder force of 6,280 pounds. When the lift is overloaded, the device will be unable to lift the load. A safety factor of 3 is required when a force of 3000 lbs. is applied to upper arm.

METHODS & CONSTRUCTION

Description

When the scissor lift is being constructed certain precautions will need to take place to maintain a precise part. The use of calipers, angle plate and other tools will help maintain the precision of the parts during measuring and assembly.

The use of the CWU machine shop, plasma table, and other resources will be used in this project to complete the project on time and on budget. Assembly of the scissor lift to the trailer frame and the dump bed will happen on location.

Drawing tree

The drawing tree is located in Appendix B. Looking at the Drawing tree shows the steps of operation for the construction process of the dump bed. Following this tree will ensure the right steps and operation occur at the proper time so nothing is started before it needs to. To finish the scissor assembly, the DB-UA-2 and DB-LA-2 will be pinned together at their location and the cylinder will be pinned at one end to DB-LA-2 and pinned at the opposite end to the DB-UA-2 at their location. Look at Appendix C for device drawings and assemblies. This scissor assembly will be pinned to the DB-LF and the DB-UF.

Parts List and Labels

The parts list is located in Appendix D. The parts list indicates part number, which can also be referenced by drawing number and a description of what the part is. The parts list also summarizes the number of parts needed for each assembly.

Manufacturing Issues

No manufacturing issues were anticipated, however a few unforeseen issues did arise and they were solved and rectified. Three issues that arise were when using the plasma table, welding members together and having aliment issues. When cutting the .4 inch thick steel with the plasma table the breaker would trip after a six inches of cutting because it would over heat the unit. To not trip the breaker when cutting, the cut was stopped ever four inches to let the unit cool down for a minute and then started again to cut another four inches. When welding bushing onto the lower arm there was heat distortion. This caused the ends of the arms to rise up and the holes were not parallel to one another. To fix this issue the 5-ton pneumatic press was used to restrain the ends. The aliment issues was also fixed when lower arms were straighten out.

Discussion of Process

First order of operations is to cut desired shapes of arms, then drill out the holes, and finally de-bur the edges. Next machine pins on the lathe to desired dimensions.

- To cut arms into desired shape using the plasma cutter, drill and ream holes to appropriate size.
- Machine pins to desired diameter, then drill in bolt holes to limit movement of pins.
- Fabricate lower and upper frame assembly.
- Assemble scissor lift parts DB-UA-2 to DB-LA-2, DB-LP-4-1, and DB-LP-4-2.
- Attach the scissor lift assembly to lower and upper frame assembly.
- Install the dump frame to the trailer frame.

TESTING METHOD

Introduction

In order to have a functional device there are several requirement to be fulfilled to determine if the device is successful. Test will be done to test the design requirements of the device that are listed on page 6. Hydraulic pressures will be in biggest interest in the tests. The calculated prediction with a .5 gpm pump is that it will take 62 seconds to lift 500 pound to lift, dump and lower the load. Data acquisition will be performed by recoding weight in bed, angle of lift, and pressure required to lift load. This testing will be done during April and May 2015.

Approach

To test the device adequate resources will be needed to perform the test. Testing will require 500 lbs. of material, a scale, a five gallon bucket, an iPhone with angle finder, a pressure gauge, hydraulic pump and a location to do the test. Data will be capture by video the process and recording the necessary values of the test like angle, PSI, and load. The device has an operational limit max pressure of 3000 PSI and should not exceed that incase of failure. Precision and accuracy will depend on the measuring equipment and repeating the tests enough time to get an average.

Test Procedure

The testing should be able to be completed within an hour, including set up and tear down. The test will be performed at the Novak Farm.

First load concert bags, four 80 pound bags and three 60 pound bags that equals 500 pounds, load it so it is centered on the bed. After the dump bed is loaded, turn on the hydraulic system and pull lever to lift the load. Measure angle at full lift, pressure to lift load, time to lift and lower load, and weight of load. Repeat four more times.

There should be very little risk in this test. The test is not exciting the maxim load of the device and should not fail. Safety is vary important in this test, the potential of lowering the bed onto an extremity could be possible. To keep everyone safe during the test communication needs to be present, before the lift is lifted operator needs to call out “lifting” and hear the ok to lift. The same thing needs to be present when lowering the lowed, operator calls out “lowering” and waits for the ok before lowering. A clear path around the trailer needs to be present to not cause any tripping hazards. The test will be considered successful if the load can be lifted and lowered.

Deliverables

There are five parameter that this test will be testing. They are size of the device, angle of tilt, achieve angle with six inch stroke cylinder, lift 500 pounds centered on dump bed, and lift with an input pressure of 1000 PSI. The test will be successful if the device can get to a 40 degree angle, use a stoke of 6 inches, lift 500 pound load under 1000 PSI. Reference Appendix H for results.

After testing the device it was able to lift 500 pounds centered on the bed with an input pressure of 1200 PSI. The calculated lifting pressure of 1000 PSI came from a bed weight of 100 pounds. With 200 more PSI required to lift the load then what was calculated was due to a under estimate of the bed weight which is closer to 250 to 300 pounds. The pressure to lift the bed with no load was 700 PSI. The angle achieve was 39 degrees and has a number of factors why it did not achieve 40 degrees, one was is that the mounting points of the device could be off by one inch and would have changed the angle by a degree. 39 degrees will be sufficient to dump a load and will not decrees the efficiency of the device.

Over all the testing was a success. The 1200 PSI to lift the load and bed was due to a under estimate of the bed weight, it only took 500 PSI to lift the load. With the angle being 39 degrees witch also pass the test and will be consisted successful.

BUDGET/SCHEDULE/PROJECT MANAGEMENT

Proposed Budget

The proposed budget will include all the material needed for the project. A parts list is shown in Appendix D. A budget is shown in Appendix E. Materials will be purchased from local hardware stores, McMaster-Carr and Surplus Center.

- Labor: 224.5 hours of labor are estimated to complete this project. Labor will be performed by Mr. Zachary Pate, valuing his time at $17 per hour. No labor outsourcing will be needed because Zachary Pate has the necessary skills to produce this device. Help with installing the lift may be needed.

After completing the project total time spent was 230.8 hours. An underestimation of extra hours come from time spent writing the proposal and constructing a frame for the lift.

- Estimated Total Cost: The estimated budget for this project is $763.44 The budget took into account the overall cost to purchase materials. Anticipated cost with donated materials is $98.73 Reference Appendix E for individual part cost. Total cost spent out of pocket was $110.35. This was $11.62 over budget, making the overall cost $775.06 to construct a new lift.

- Funding Sources: The funding for this project will come out of pocket, with some resources donated by the Novak Farm.

Proposed Schedule

The schedule will lay out a reasonable time frame in which the project will be completed. It will cover the proposal, manufacturing, and testing of the device. The schedule for this project is shown in Appendix F, shown as a Gantt chart. This project will be completed by the last week of spring quarter.

Project Management

This design is susceptible to three major risks including cost, time, and manufacturability. The risk associated with costs is defined by staying within the specified budget and will depend on finding the materials at prices that were researched for this purpose. Time constraints for the project also produce a risk because the project will need to be designed, manufactured, and tested within a 30 week time period. The last risk factor is manufacturability; it will need to be fabricated to the anticipated design parameters.

Safety is an important part of this project. Injury will be prevented by consistent use of personal protection equipment as needed. The use of hydraulics with high pressure lifting heave loads creates opportunity for injury. Common sense will be needed when building and operating the device.

I. Human Resources: The lead investigator is responsible for the engineering, machining, and construction. The individual is also responsible for finding additional resources when needed.

II. Physical Resources: Central Washington University has a full machine shop as well as other labs that are available to students. The Novak Farm will be used as a location for assembly.

III. Soft Resources: This project heavily depended on the use of software. Software being used is Solid Works, Microsoft Office, MasterCam, and CNC software.

IV. Financial Resources: A financial resource for this project is, Novak Farm. They will donate some material for the project. The lead investigator will provide funding for the rest of the project.

DISCUSSION

Design Evolution

The project started out as an idea sketched on paper. After having difficulty finding the workable geometry by hand, it was modeled with two 1"x.5"x20" linking arms in SolidWorks, helping find the necessary dimensions. By trial and error, the location of the pivot points was identified to find the correct placement to achieve a 40º angle with six inches of stroke. After some analysis was done on the two linking arms, and found that the input force to lift the dump bed was over 4000 pounds and pointed too much in the x-axis making it unable to lift the designated load of 500 pounds. Then a redesign of the upper linking arm connected to the cylinder was designed to be more practical by changing the input angle of the cylinder to 9.7 degrees and lowed the input force to 2758 pounds. See Figure 5, Appendix A. This designed changed improved the device by lowering the necessary input force and making capable of lifting a larger load. Next, after learning that the plasma table could not cut 1/2 inch thick steel, the linking arm was analyzed using 3/8 inch thick steel and determined it would not yield using a thinner steel, see Appendix A, Figure 10 and 14.

Project Risk Analysis

Working with high pressure and heavy loads involves a significant safety risk. The highest risk could be identified as a failure of the scissor arms and if precautions are not followed, could lead to bodily injury. Event of injury is low, but could accrue if the system is overloaded or someone places an extremity into the lift as it is expanding. With this in mind, the arms have been engineered as the strongest component, purposefully designing the cylinder to be the weakest link, thus reducing the event of scissor arm failure.

Successful

After testing is completed the device and design will be considered successful or not. Success will also depend on if the device is functional and can be completed in time and on budget.

After constructing, and testing the device it was considered a successful. It was able to lift the 500 pounds and tilted to a adequate angle to dump the load.

Next Phase

The next phase is to use the product at the Novak Farm for daily use. After observing the device in action a redesign could be made to improve the device.

CONCLUSION

The Dump Bed Lifting Mechanism has conceived and analyzed as a device that meets the function requirements asked for. The necessary parts have been listed and a description of how they will be created has been presented. By staying within a specified reasonable budget, incorporating commonly found materials into its design, an efficient, compact functional device, it is ready to be manufactured.

Analysis had been performed that will substantiate the feasibility and probable success of this project. Calculations have been made to show that minimum expectations will be met for the success of the project. The device has been thoroughly contemplated and analyzed in its design, usefulness and functionality, thus proving by its design parameters an efficient, less costly solution to a device that can be commonly used in an everyday farm setting.

This project meets all the requirements for a successful senior project, including having:

- Substantive engineering merit by producing efficient lifting capabilities with a compact size.
- Compact size benefits include lower costs predicted by the projected budget.
- Principle investigator will have produced a device that substantially eliminates most of the physical labor required to move material and significantly lessens the time required to do so.

ACKNOWLEDGEMENTS

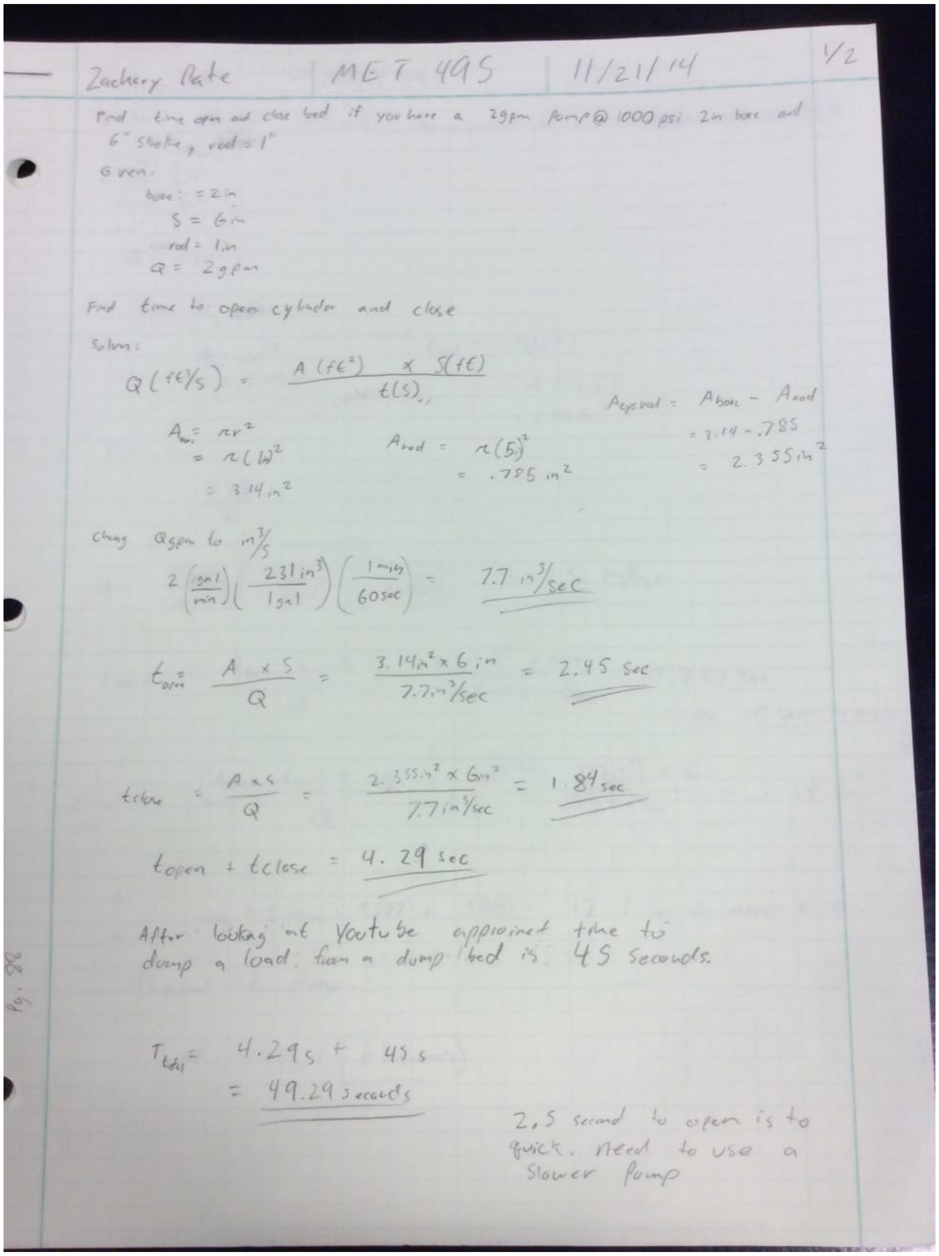
Thanks are due to Dr. Craig Johnson, Mr. Roger Beardsley, and Mr. Charles Pringle for their mentoring and advice. Central Washington University for the use of their machine shop and facilities, tools, software, references and resources required for the completion of this project. Much appreciation is also due to Mr. Geoffrey Pate, an outside entity for his mentoring of the principal engineer and to the Novak Farm for donated resources.

<u>Reference</u>

Hibbeler, R.C. (2014). *Statics & Mechanics of Materials.* Boston: Pearson.

Benchmark. http://www.kgequipment.com/steel-2/hoist/

APPENDIX A - ANALYSES



Zachery Pate | MET 495 | 11/21/14 — 1/2

Find time open and close bed if you have a 2gpm pump @ 1000 psi 2in bore and 6" Stroke, rod = 1"

Given:

bore: = 2in

S = 6in

rod = 1in

Q = 2gpm

Find time to open cylinder and close

Solution:

$Q(ft^3/s) = \frac{A(ft^2) \times S(ft)}{t(s)}$

$A_{bore} = \pi r^2 = \pi(1)^2 = 3.14\ in^2$

$A_{rod} = \pi(.5)^2 = .785\ in^2$

$A_{cyl\ rod} = A_{bore} - A_{rod} = 3.14 - .785 = 2.355\ in^2$

Change Q_{gpm} to in^3/s

$2\left(\frac{gal}{min}\right)\left(\frac{231\ in^3}{1\ gal}\right)\left(\frac{1\ min}{60\ sec}\right) = 7.7\ in^3/sec$

$t_{open} = \frac{A \times S}{Q} = \frac{3.14 in^2 \times 6 in}{7.7 in^3/sec} = 2.45\ sec$

$t_{close} = \frac{A \times S}{Q} = \frac{2.355 in^2 \times 6 in}{7.7 in^3/sec} = 1.84\ sec$

$t_{open} + t_{close} = 4.29\ sec$

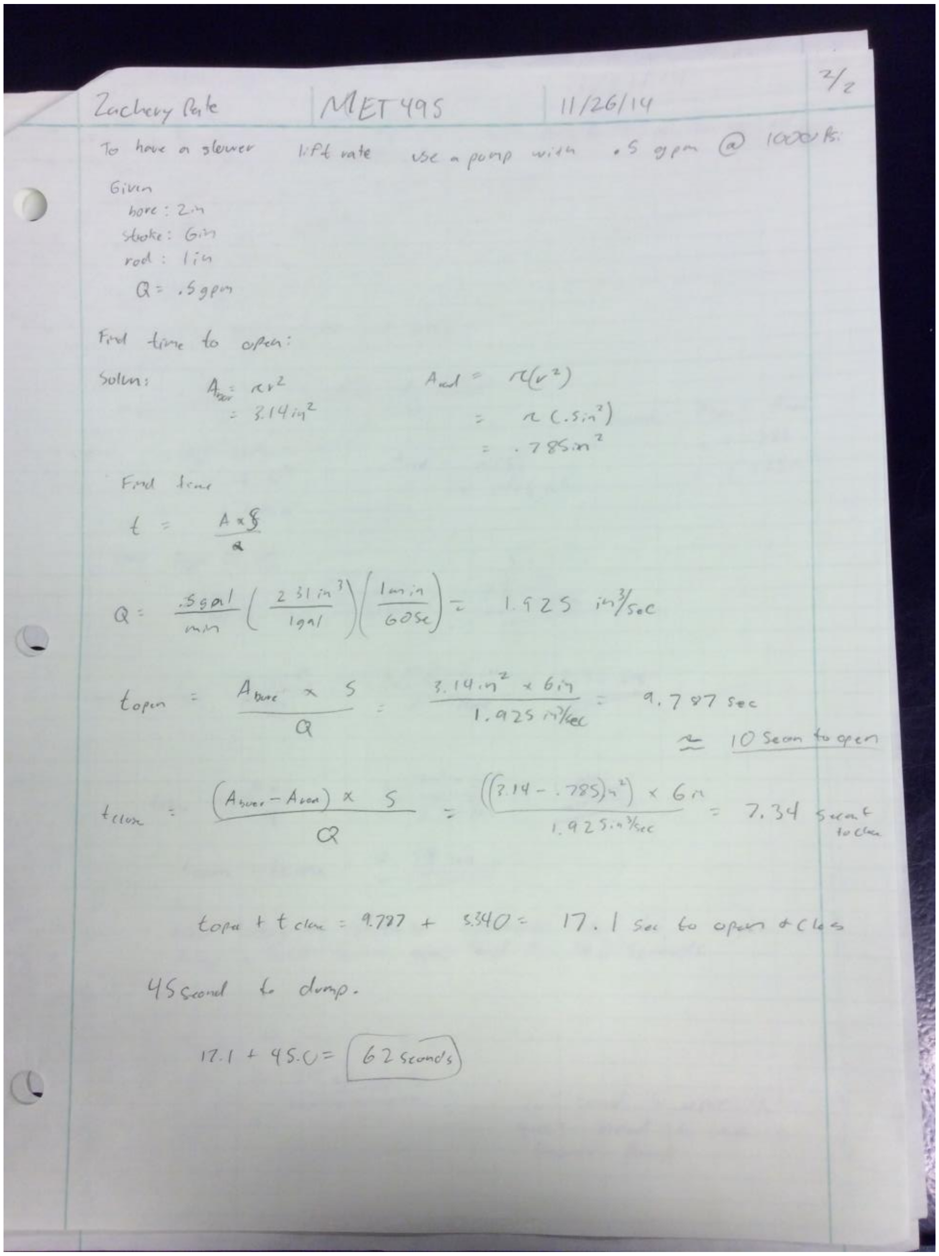
After looking at Youtube approximate time to dump a load from a dump bed is 45 seconds.

$T_{total} = 4.29s + 45s = 49.29\ seconds$

2.5 second to open is to quick. need to use a slower pump

Pg. 88

Figure 3 Time to Open Dump Bed 1 of 2



Zachery Pate MET 495 11/26/14 2/2

To have a slower lift rate use a pump with .5 gpm @ 1000 psi

Given
bore: 2 in
stroke: 6 in
rod: 1 in
Q = .5 gpm

Find time to open:

Soln: $A_{bore} = \pi r^2 = 3.14 in^2$ $A_{rod} = \pi(r^2) = \pi(.5 in^2) = .785 in^2$

Find time

$t = \frac{A \times S}{Q}$

$Q = \frac{.5 gal}{min}\left(\frac{231 in^3}{1 gal}\right)\left(\frac{1 min}{60 sec}\right) = 1.925 in^3/sec$

$t_{open} = \frac{A_{bore} \times S}{Q} = \frac{3.14 in^2 \times 6 in}{1.925 in^3/sec} = 9.787 sec$ ≈ 10 Secon to open

$t_{close} = \frac{(A_{bore} - A_{rod}) \times S}{Q} = \frac{((3.14 - .785) in^2) \times 6 in}{1.925 in^3/sec} = 7.34$ second to close

$t_{open} + t_{close} = 9.787 + 3.340 = 17.1$ sec to open & close

45 second to dump.

17.1 + 45.0 = 62 seconds

Figure 4 Time to Open Dump Bed 2 of 2

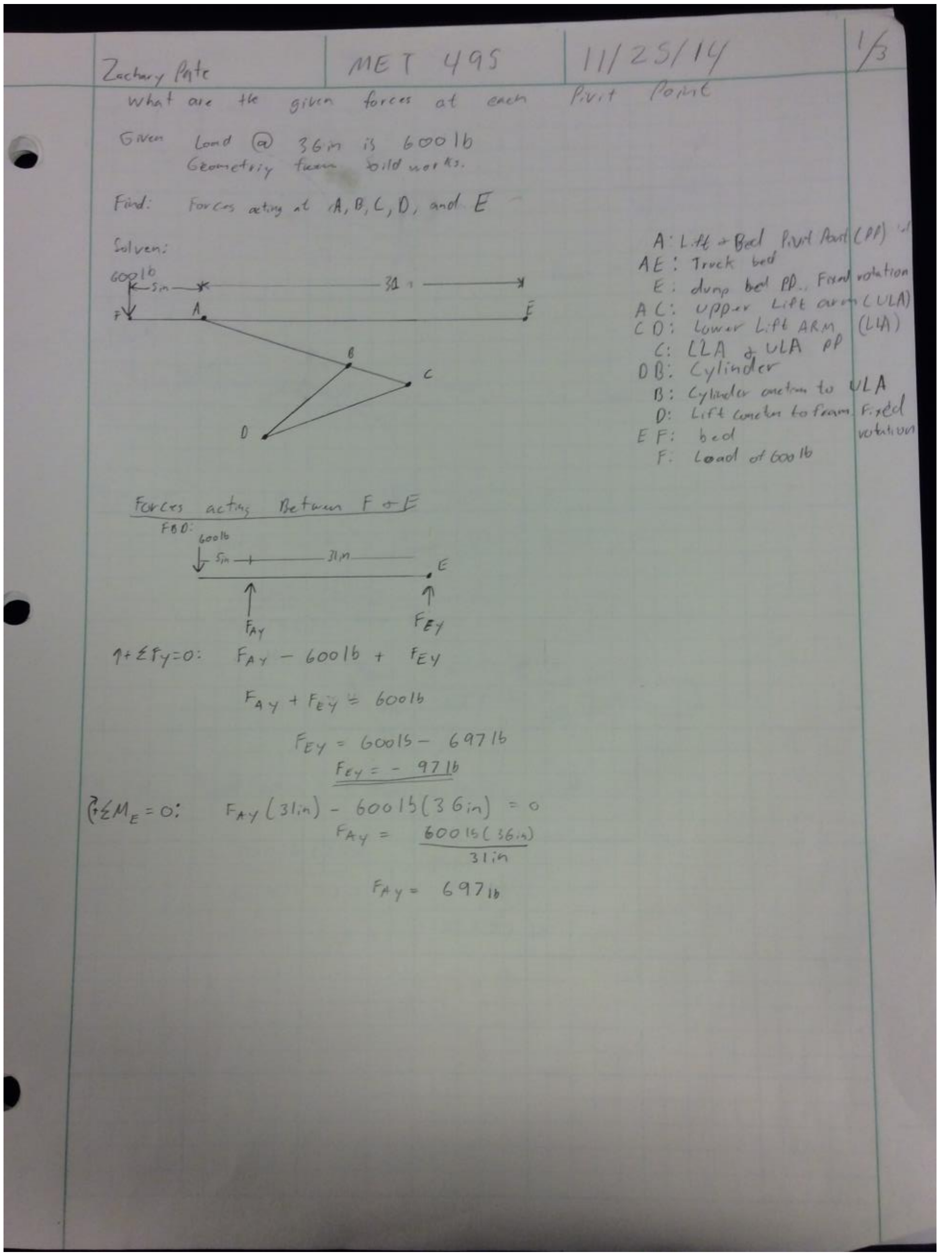


Figure 5 Analysis of Scissor Arms 1 of 3

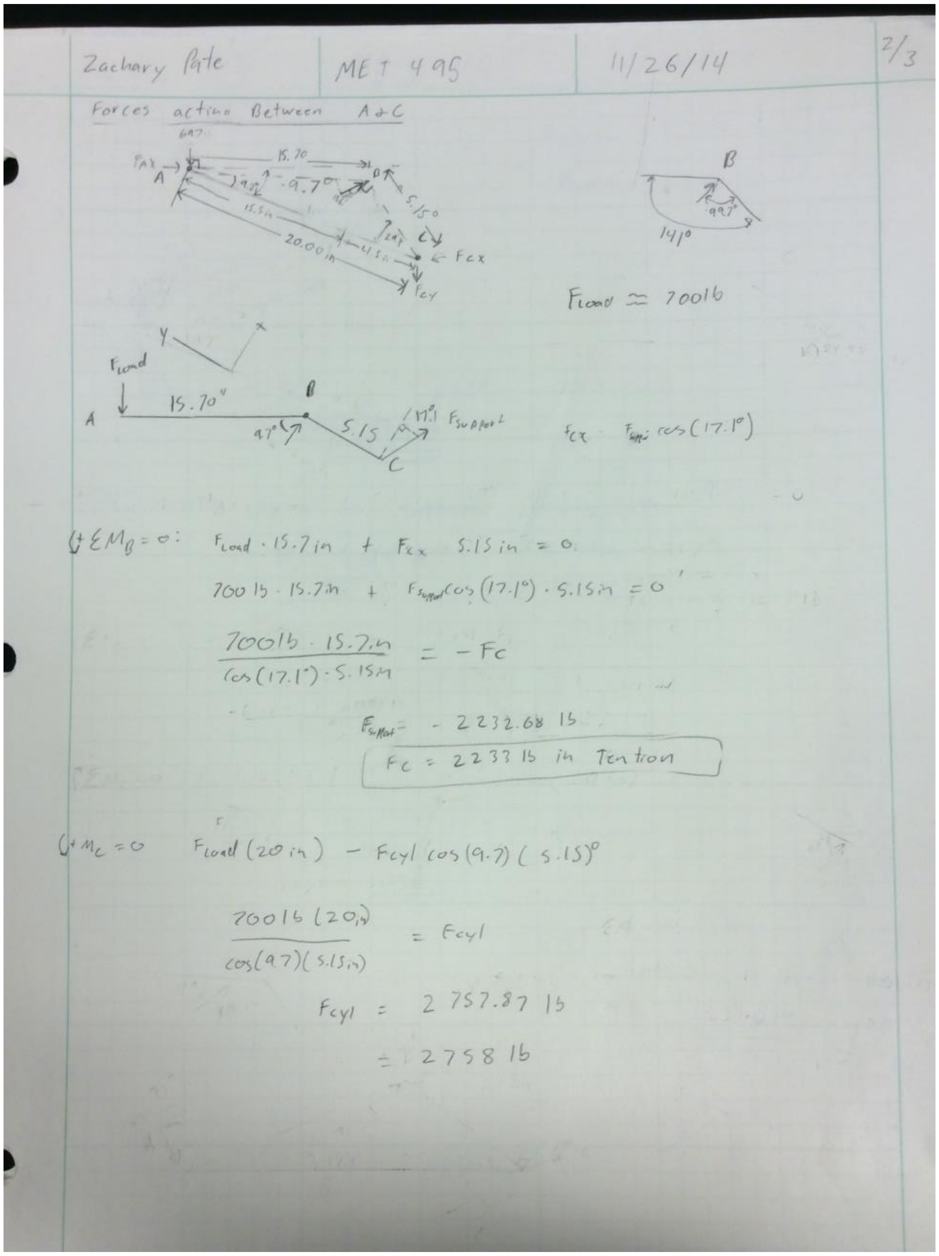
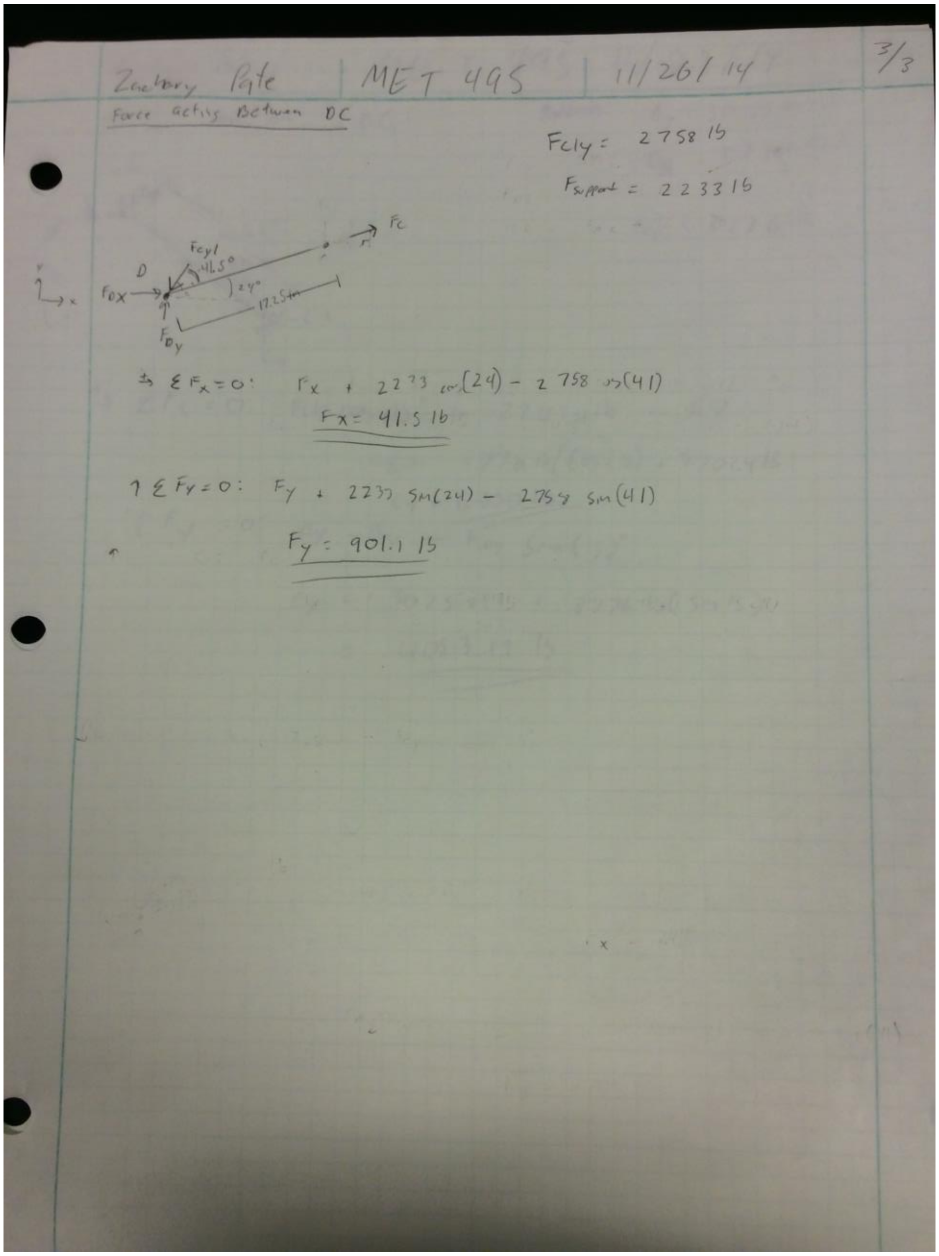


Figure 6 Analysis of Scissor Arms 2 of 3


Zachary Pate | MET 495 | 11/26/14 3/3

Force acting Between DC

Fcly = 2758 lb

Fsupport = 2233 lb

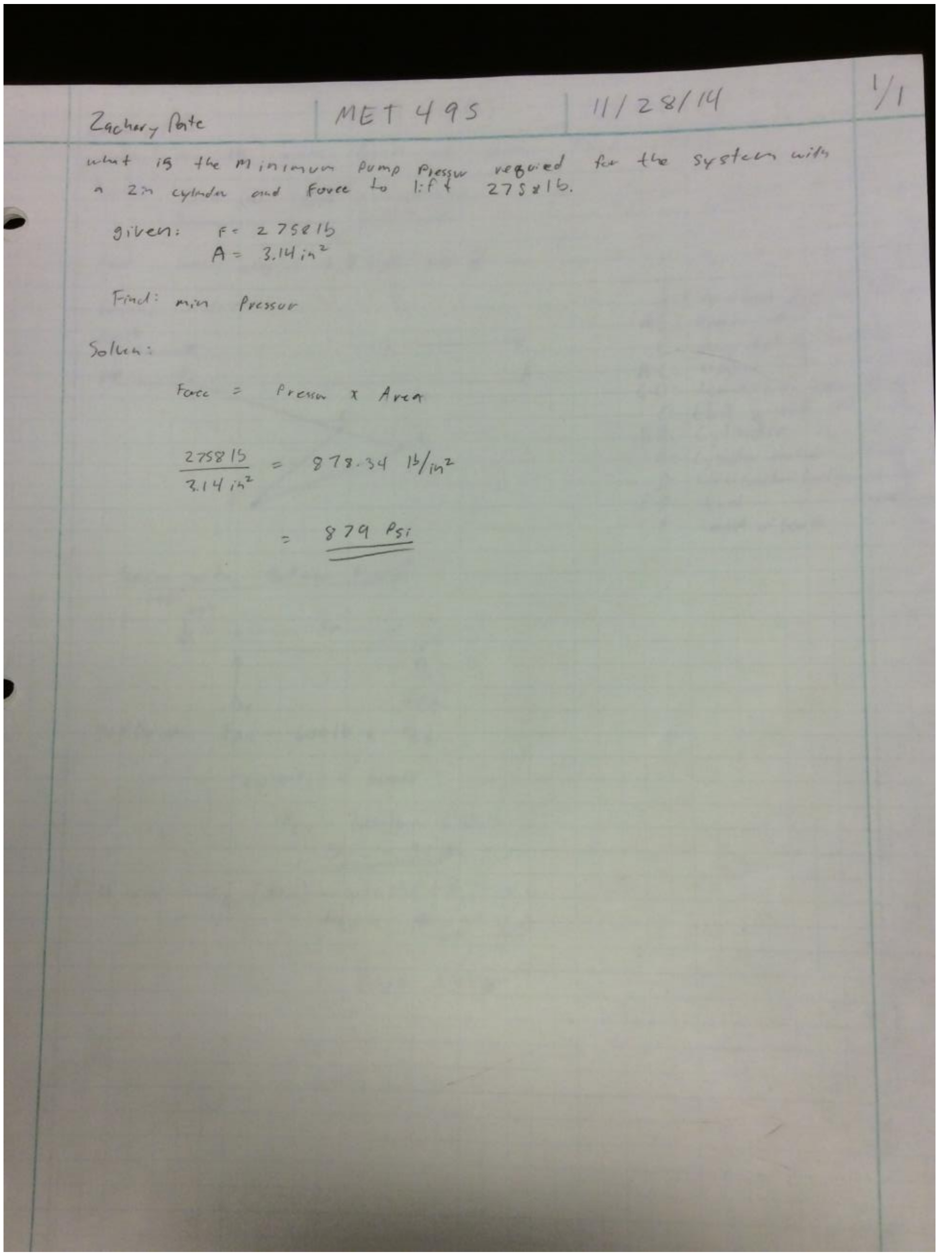
$\rightarrow \Sigma F_x = 0$: $F_x + 2233\cos(24) - 2758\cos(41)$

$F_x = 41.5$ lb

$\uparrow \Sigma F_y = 0$: $F_y + 2233\sin(24) - 2758\sin(41)$

$F_y = 901.1$ lb

Figure 7 Analysis of Scissor Arms 3 of 3


Zachary Pate | MET 495 | 11/28/14 | 1/1

what is the minimum pump pressure required for the system with a 2in cylinder and force to lift 2758 lb.

given: F = 2758 lb
A = 3.14 in²

Find: min Pressure

Solution:

Force = Pressure x Area

$\frac{2758\ lb}{3.14\ in^2} = 878.34\ lb/in^2$

$= 879\ psi$

Figure 8 Minimum Hydraulic Pressure to Lift Load

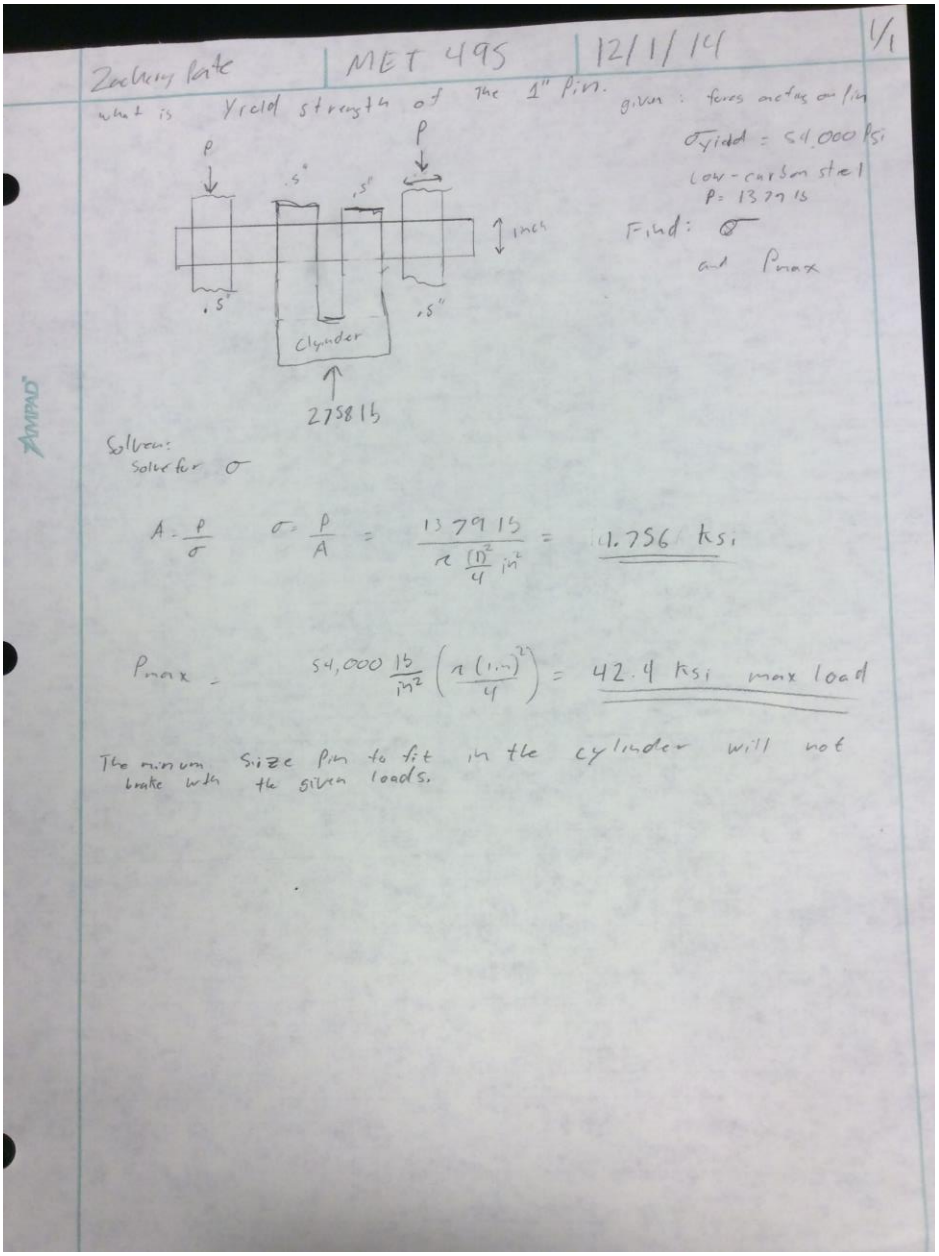


Figure 9Pin Stress

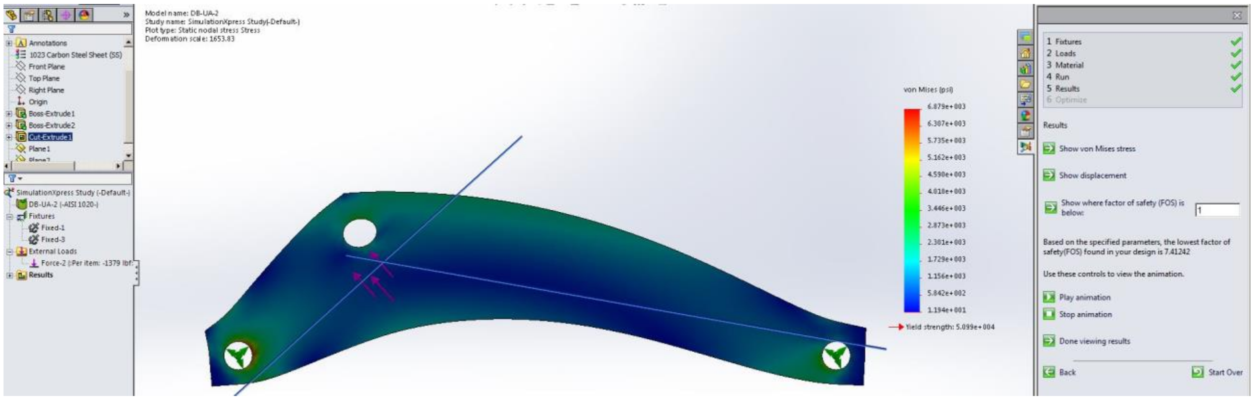


Figure 10 3/8 Thick DB-UA-2 von Mises Stress With Minimum Force to Lift Load FS 7.4

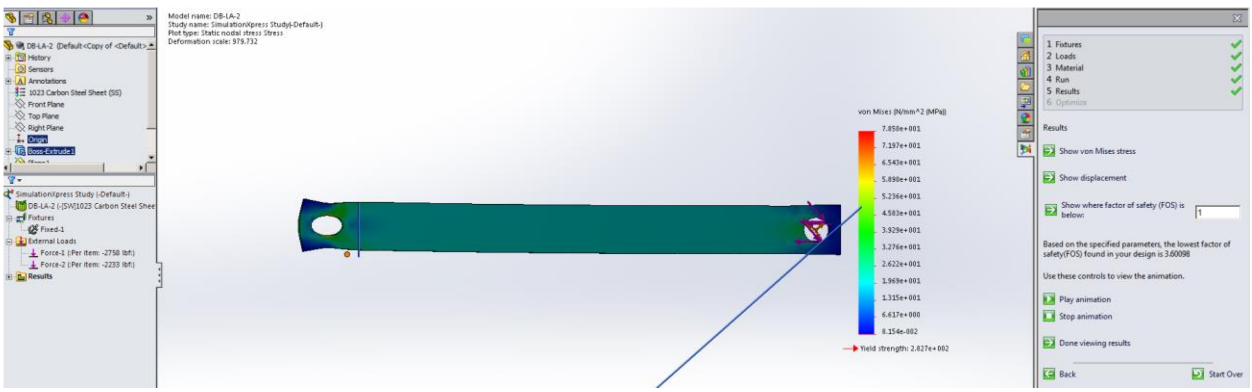


Figure 11 3/8 Thick DB-LA-2 Von Mises Stress With Minimum Force Using One Arm FS 3.6

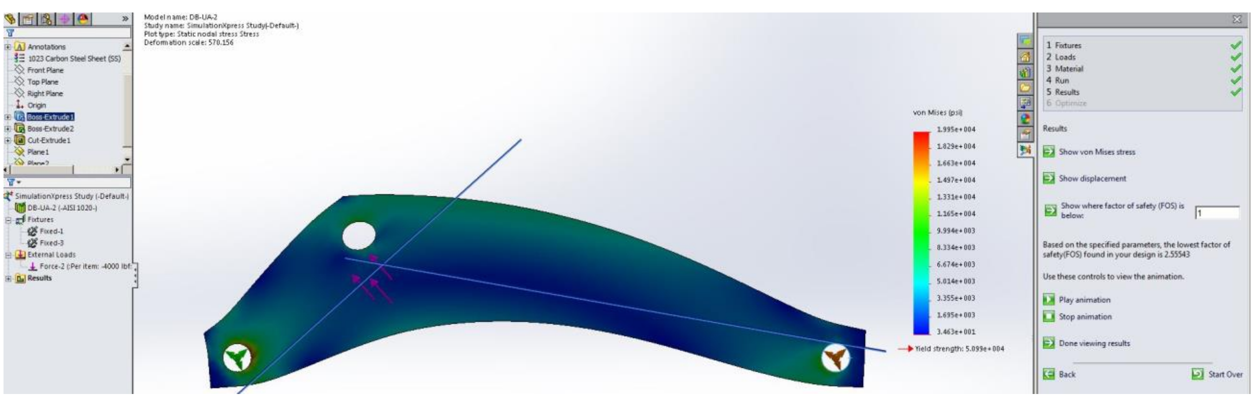


Figure 12 3/8 Think DB-UA-2Von Mises Stress Maximum Force For One Arm FS 2.6

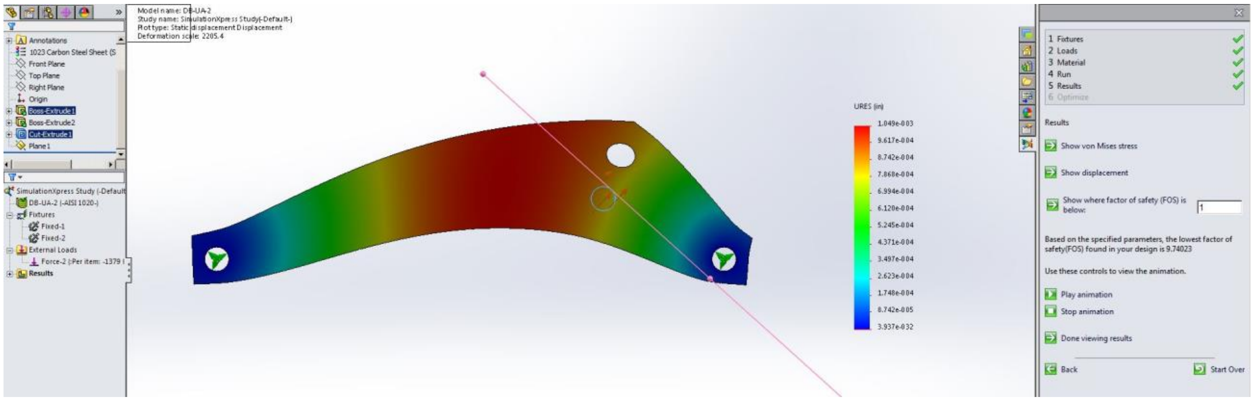


Figure 14 1/2 Thick DB-UA-2 Displacement With Minimum Force Applied to Arm FS 9.7

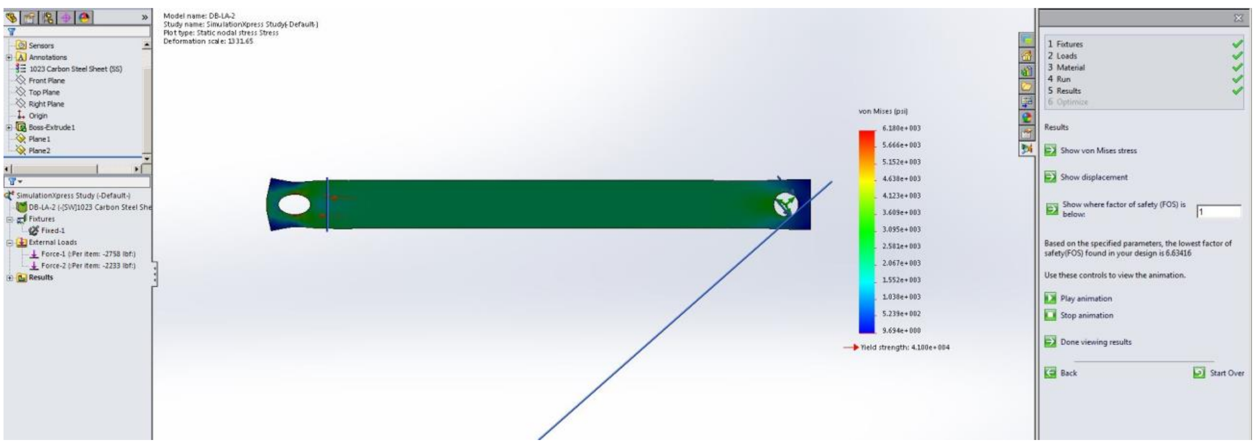


Figure 13 1/2 Think DB-LA-2 Displacement with Minimum Force Using One Arm FS 3.6

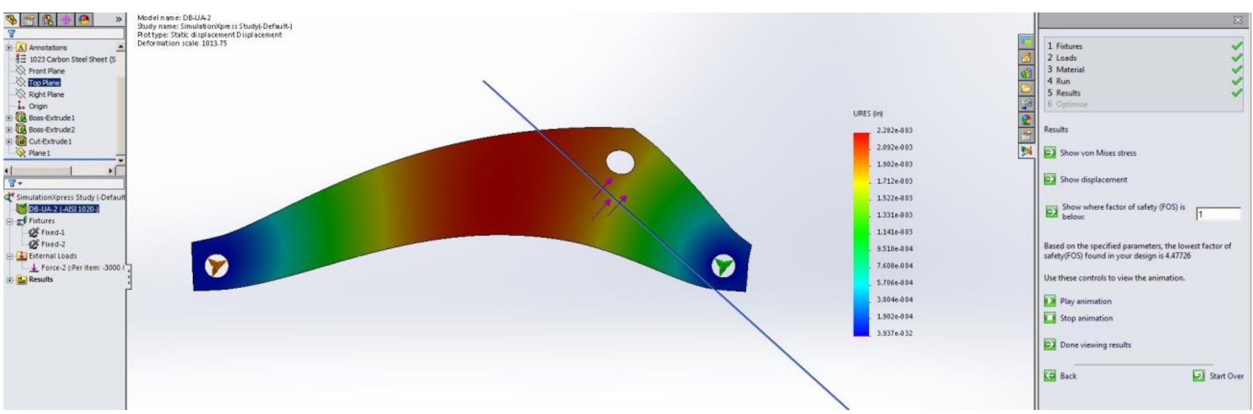
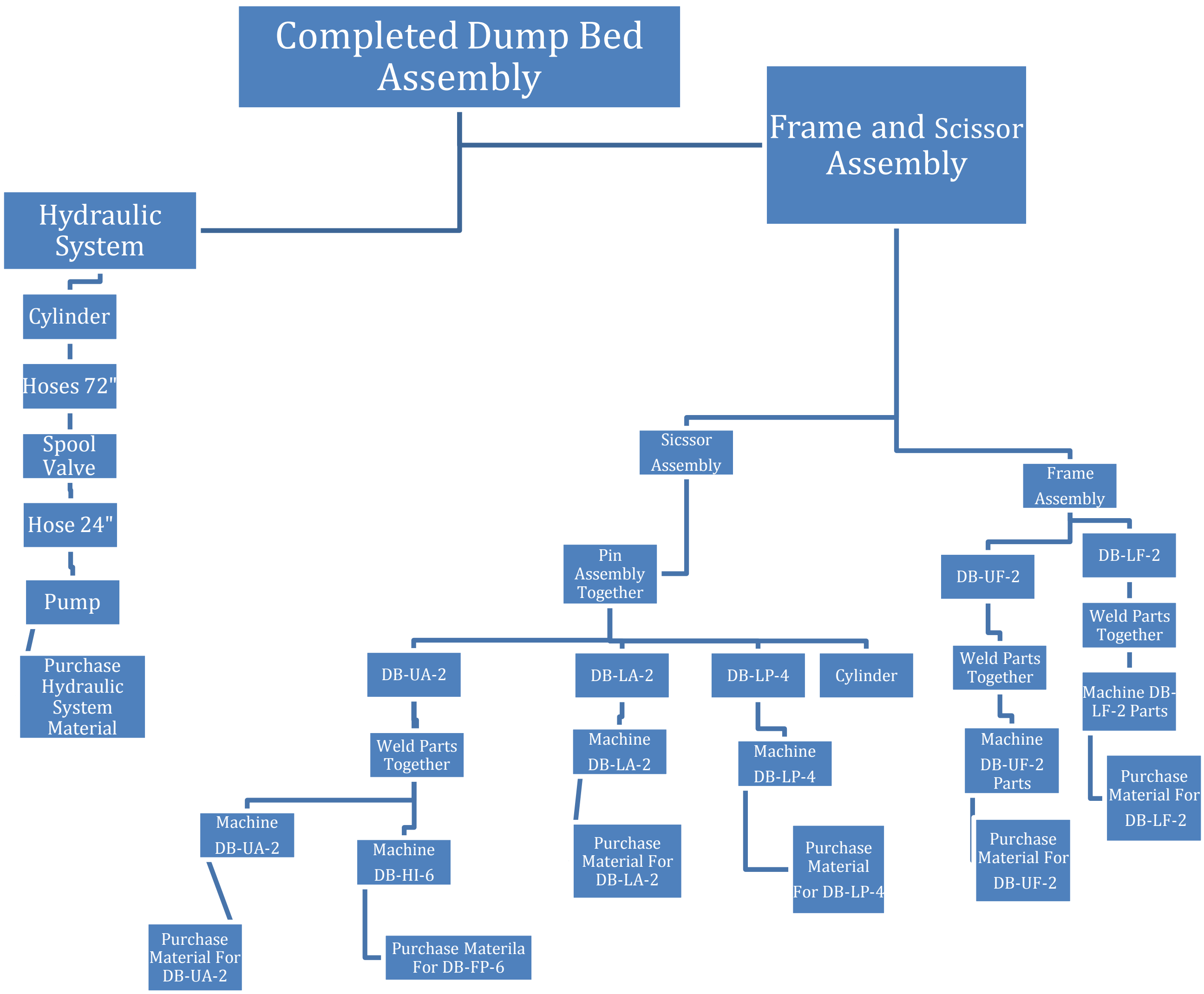


Figure 15 1/2 Thick with 3000lb Force   FS 4.7

APPENDIX B – DRAWING TREE



APPENDIX C – DRAWINGS

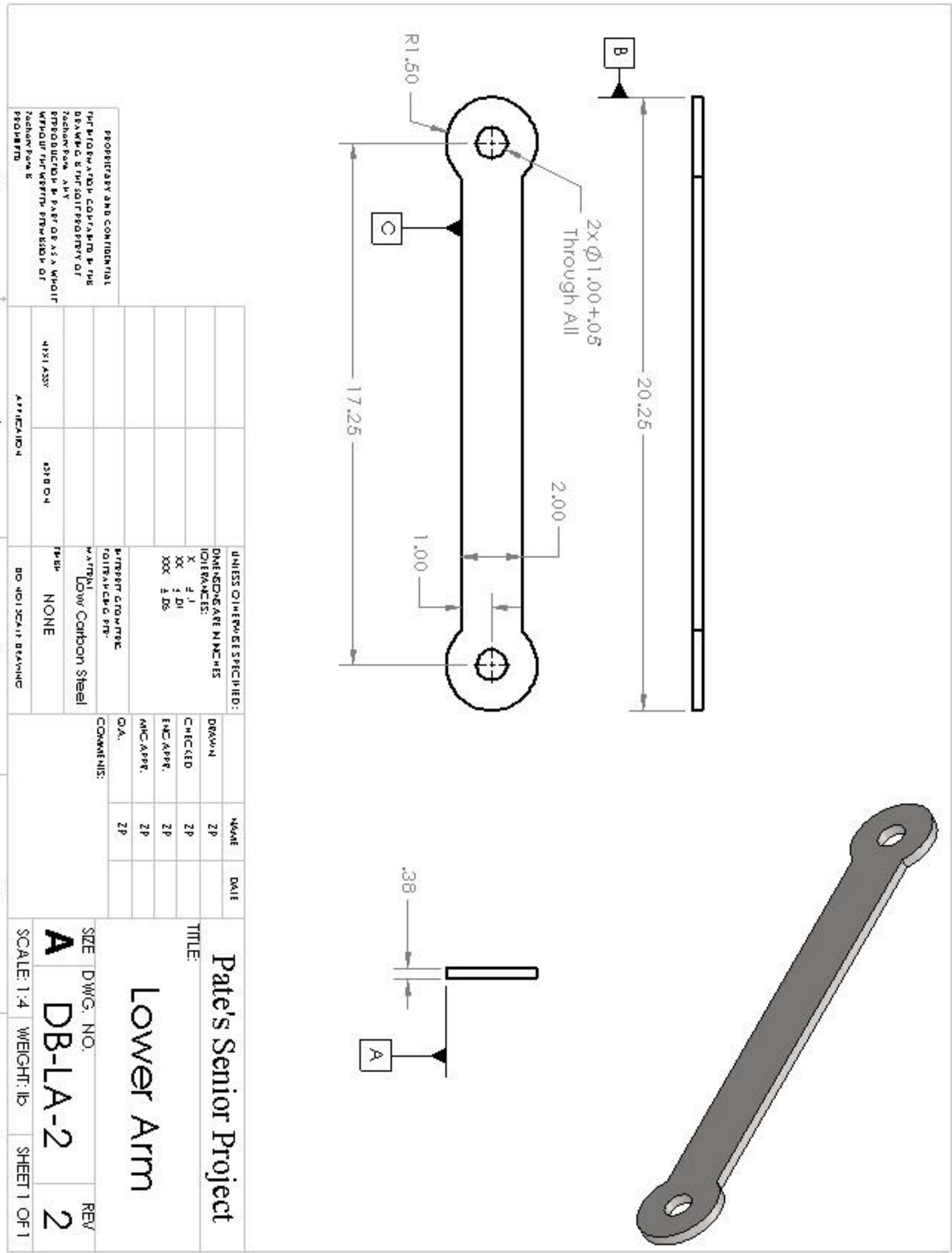


Figure 16 Lower Arm Drawing

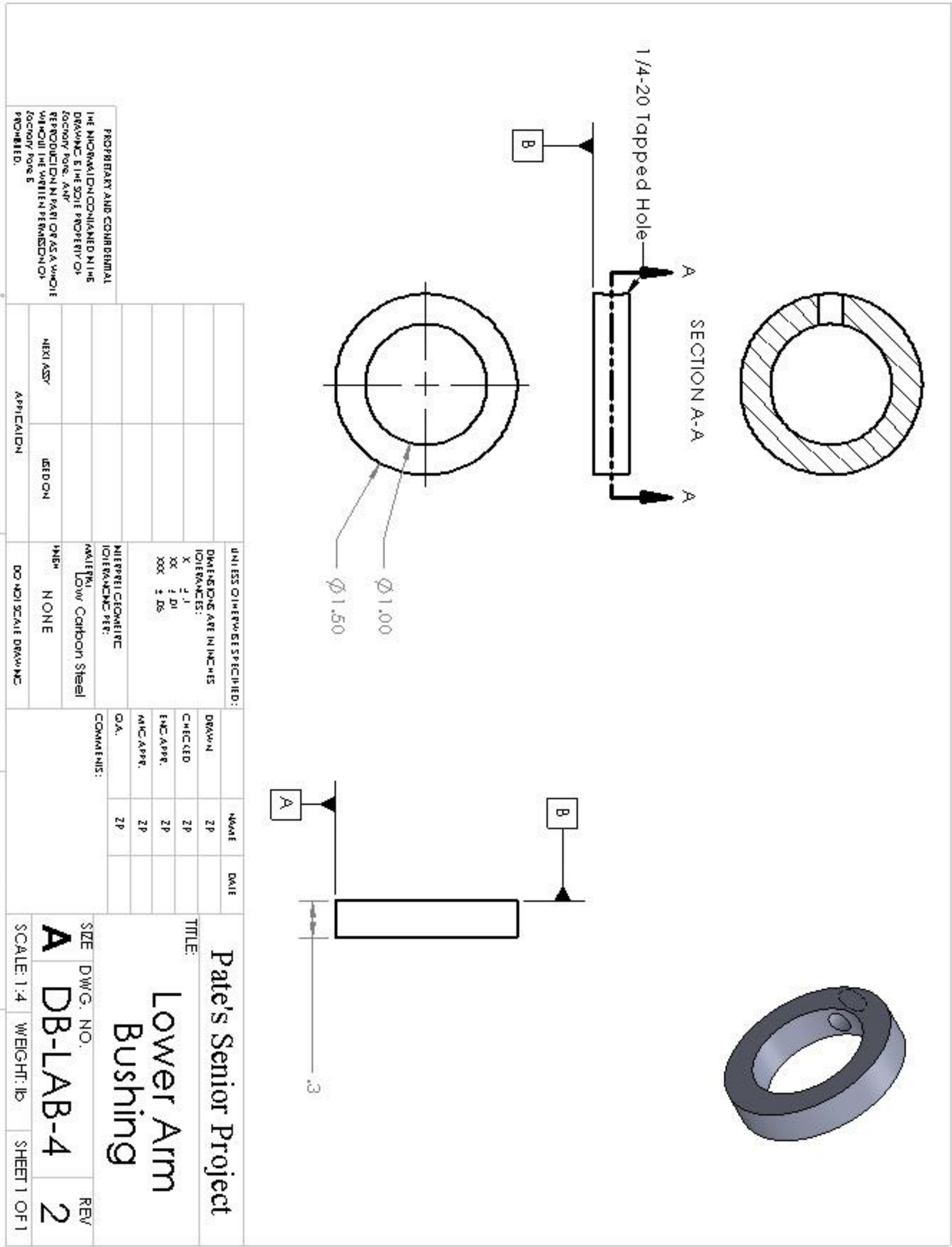


Figure 17 Lower Arm Bushing Drawing

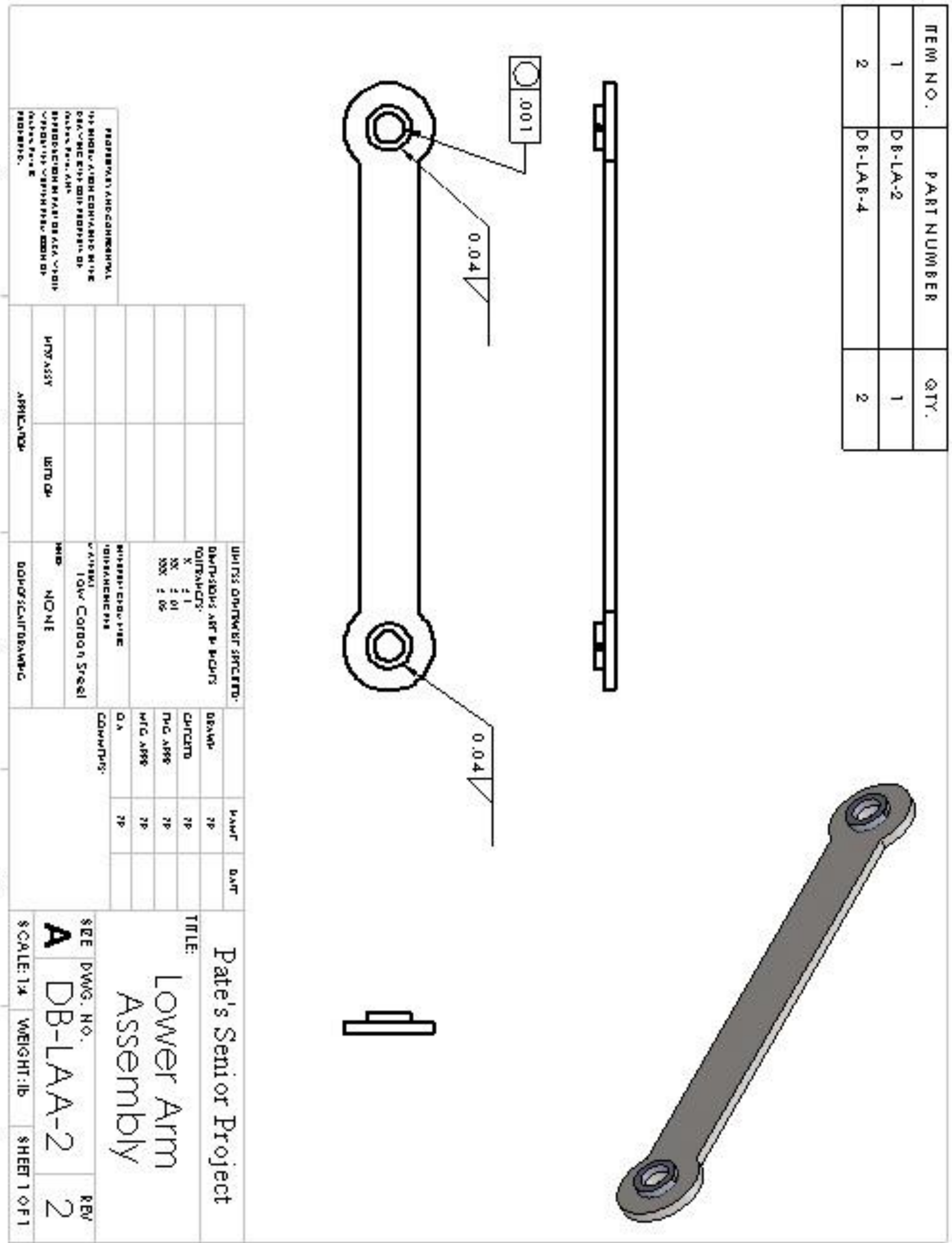


Figure 18 Lower Arm Assembly Drawing

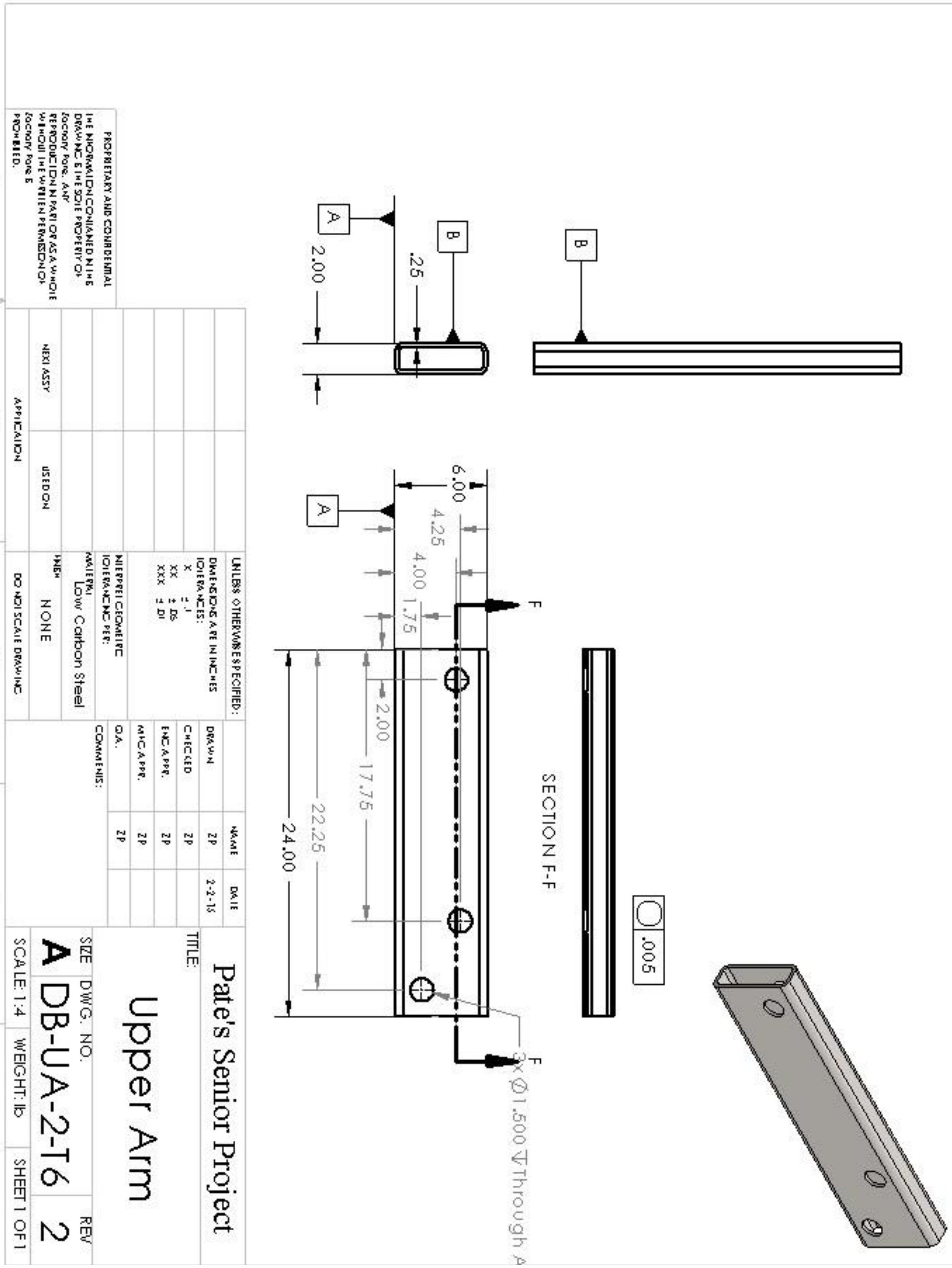


Figure 19 Upper Arm Drawing

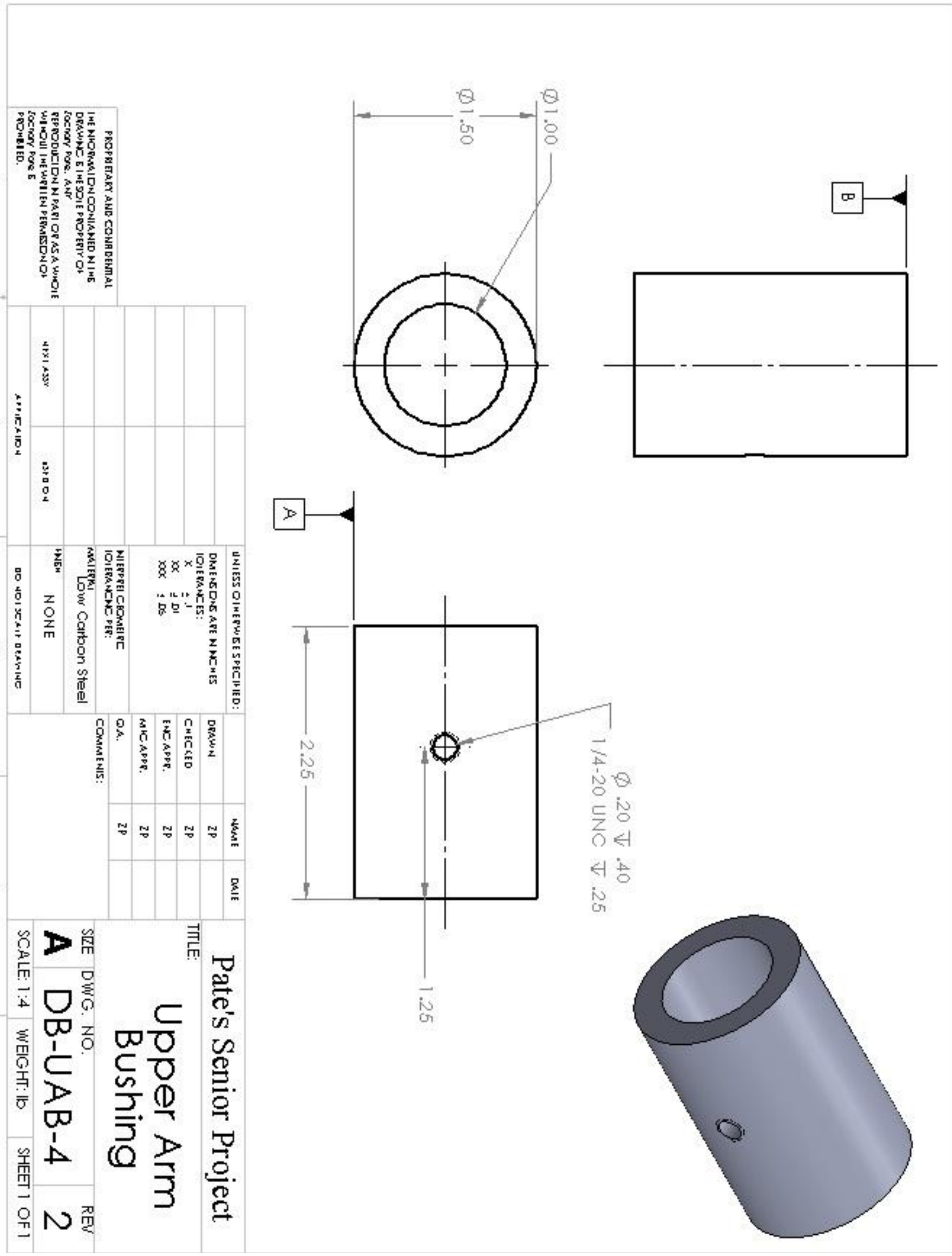


Figure 20 Upper Arm Bushing

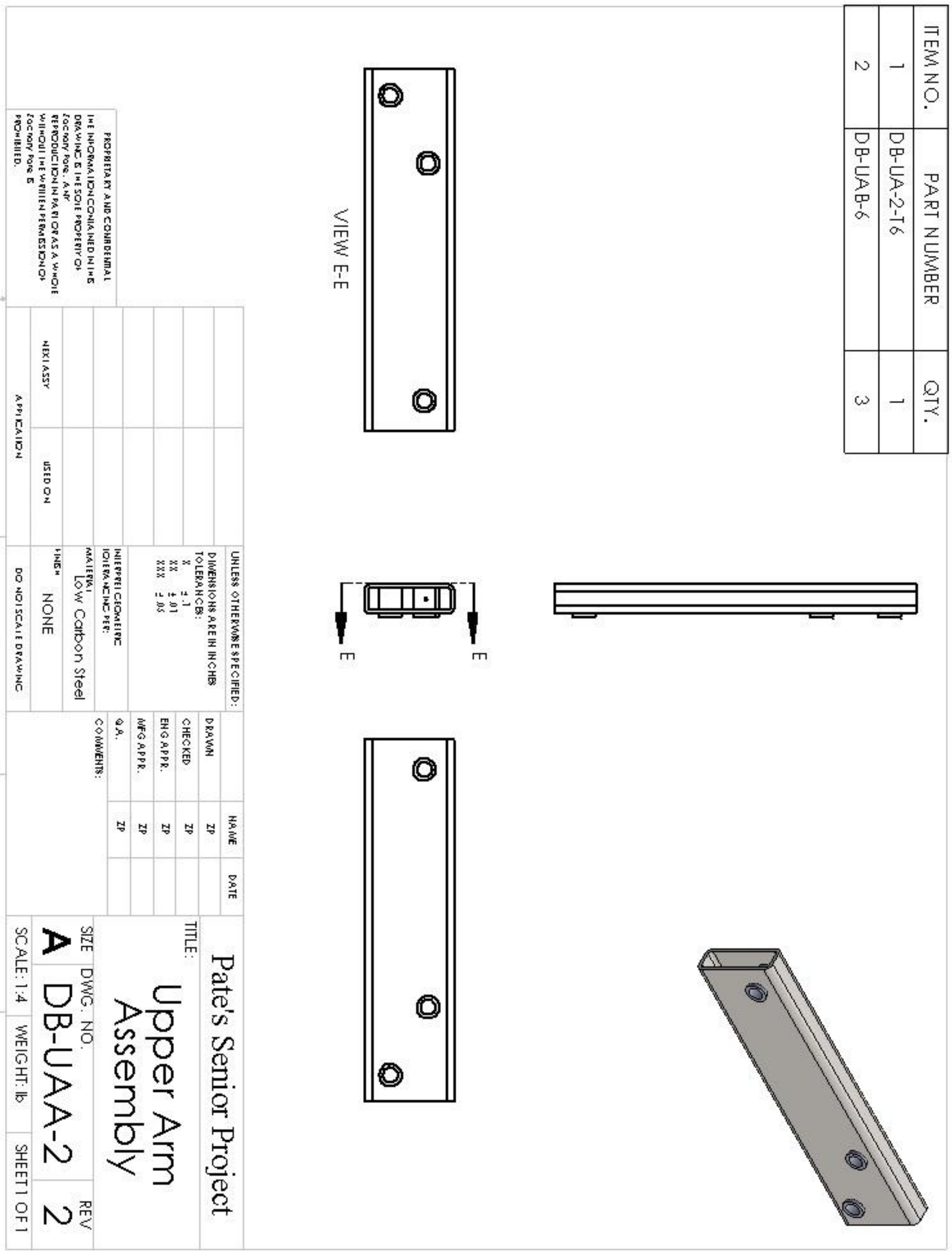


Figure 21 Upper Arm Assembly

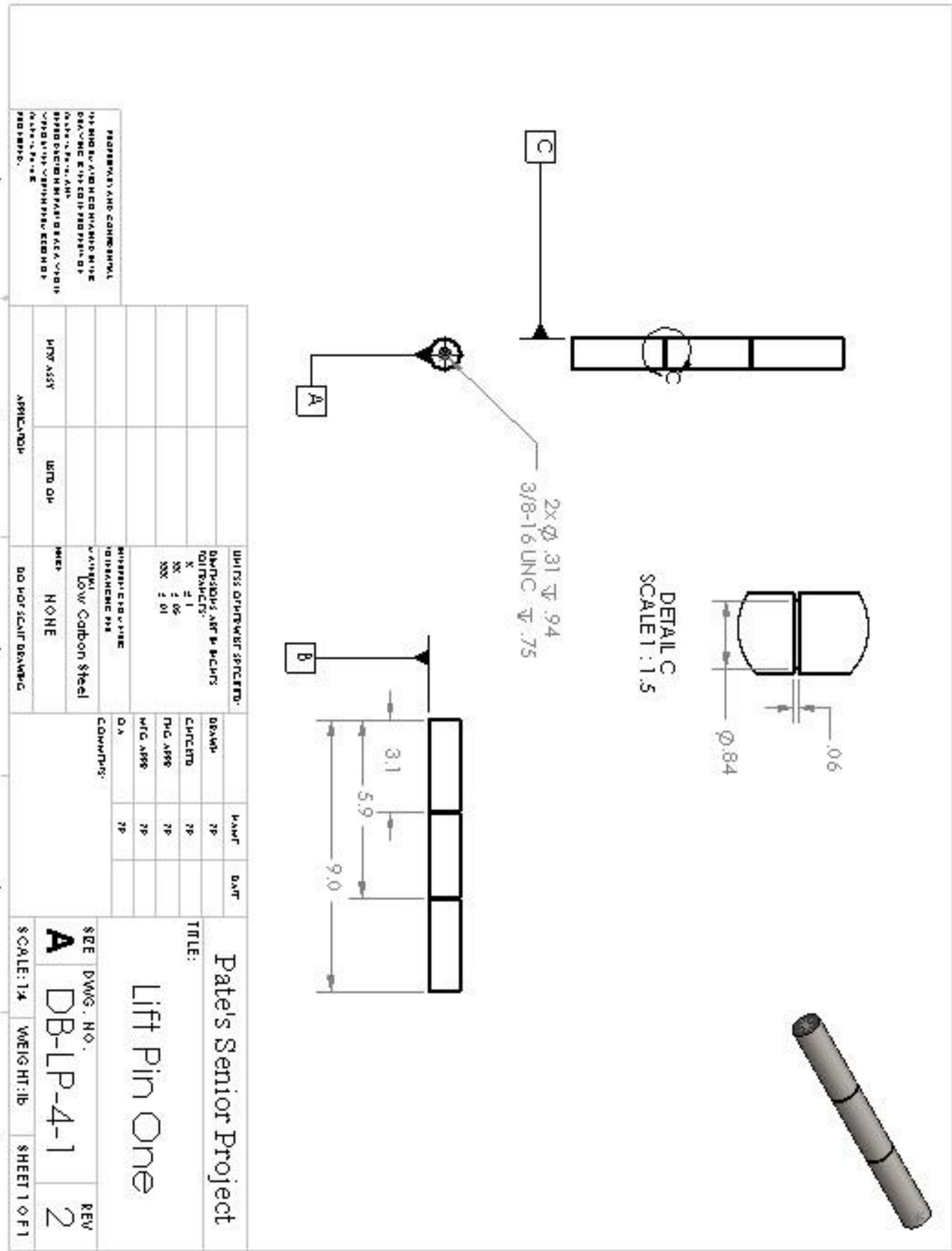


Figure 22 Lift Pin One Drawing

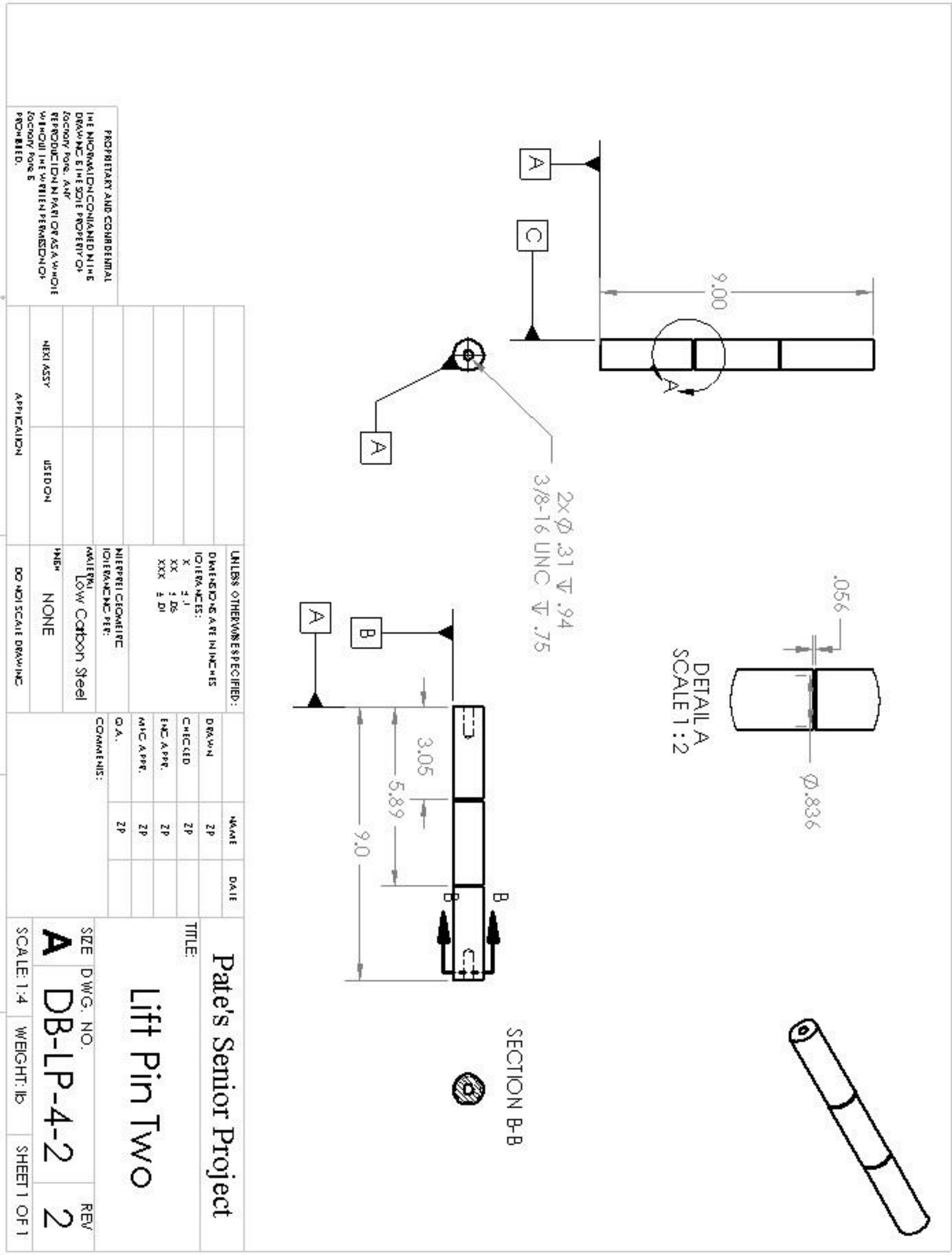


Figure 23 Lift Pin Two Drawing

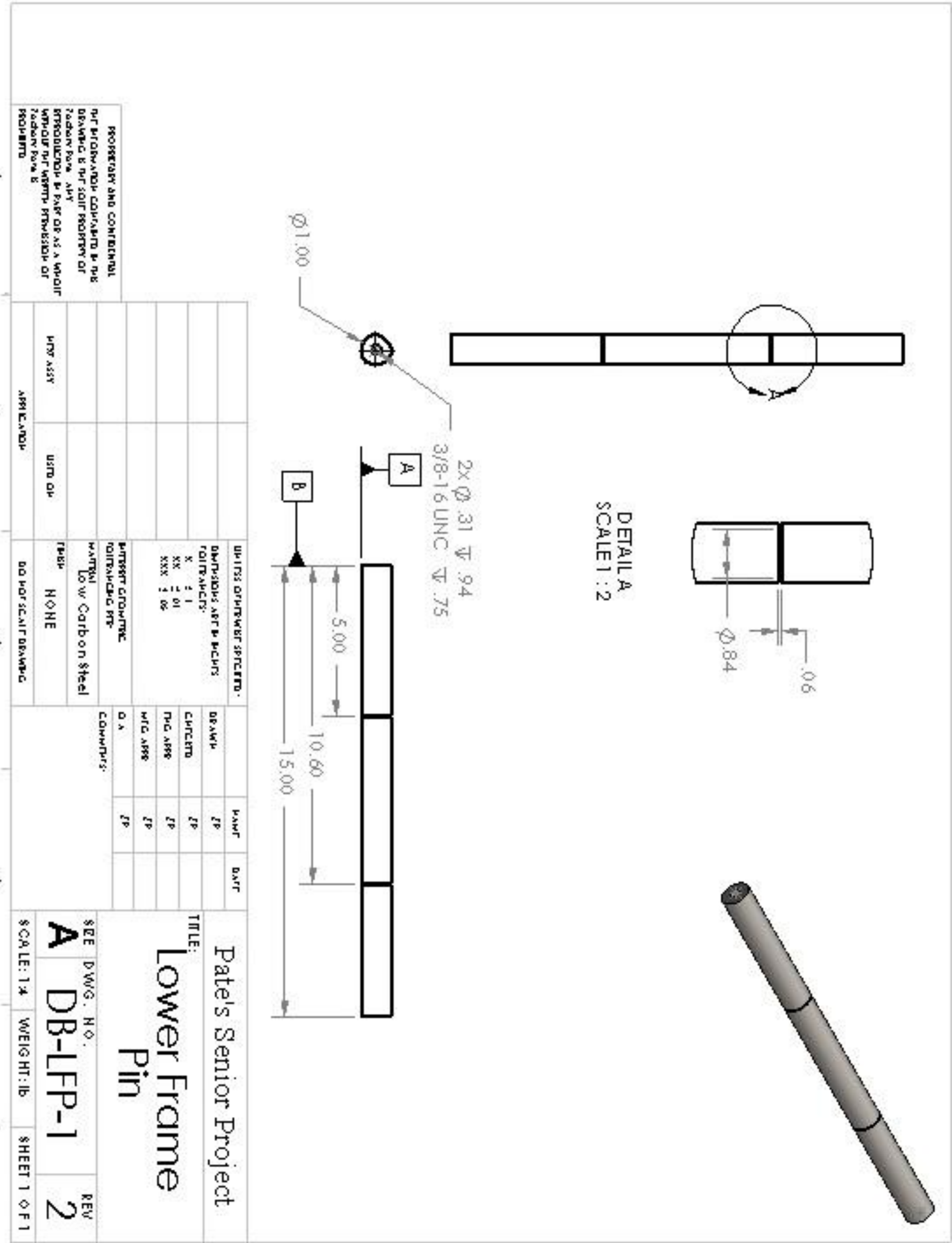


Figure 24 Lower Frame Pin

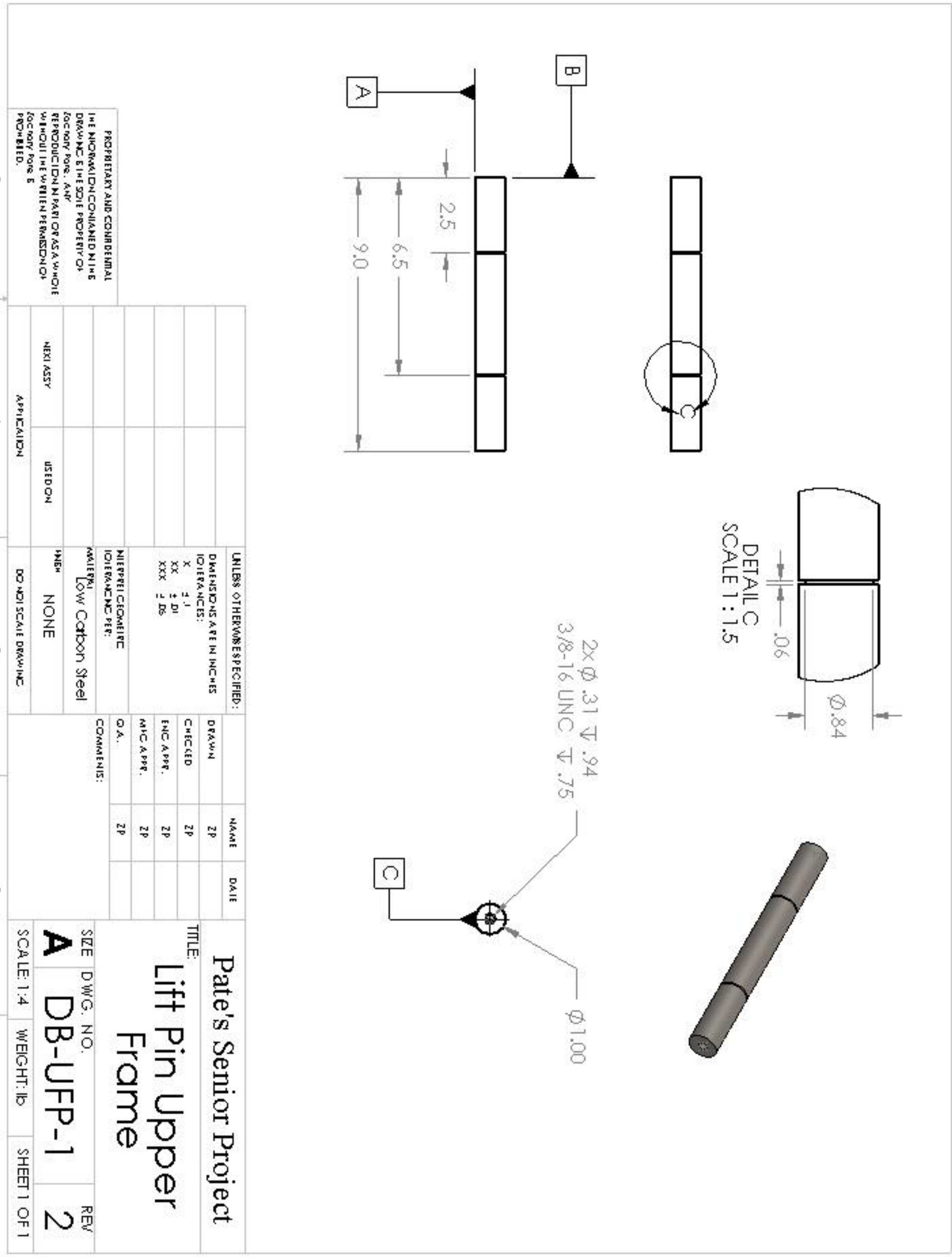


Figure 25 Lift Pin Upper Frame Drawing

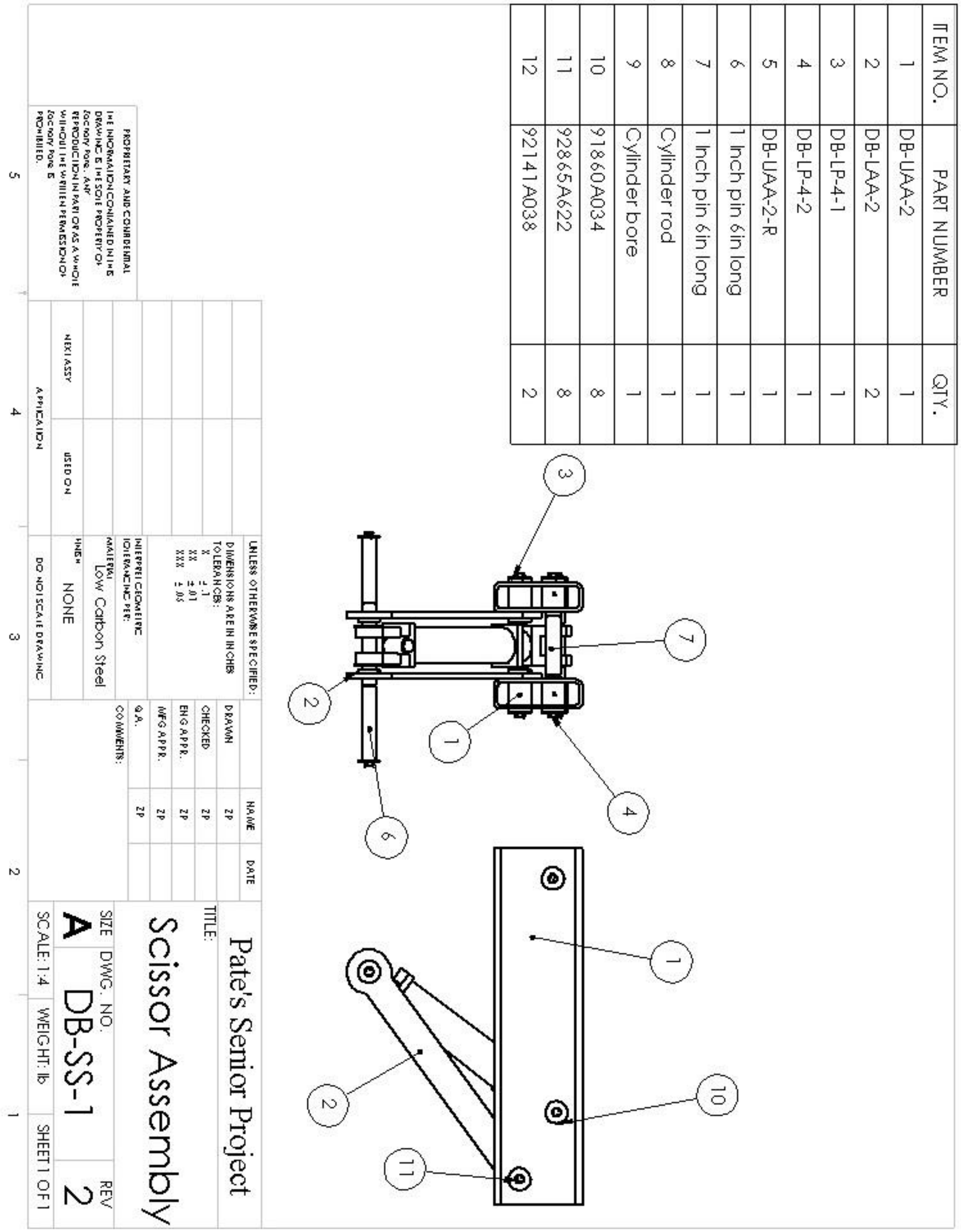


Figure 26 Scissor Assembly Drawing

APPENDIX D – PARTS LIST

Zachary Pate		Senior Project Part List	
Project Name:		Dump Bed Lifting Mechanism	
Item	Part #	Description	Quantity
1	DB-LA-2	Lift's Lower Arm	2
2	DB-UA-2	Lift's Upper Arm	2
3	DB-LP-4-1	Lift Pin UA/LA 1"dim by 9" long	1
4	DB-LP-4-2	Lift Pin UA/Cly 1"dim by 9" long	1
	DB-LAB-4	Lower Arm Bushings	4
5	DB-UAB-6	Upper Arm Bushings	6
6	HP-1	Hydraulic Pump	1
7	HC-1	Hydraulic Cylinder	1
8	HH-P-2	Hydraulic Hose 24"	2
9	HH-C-2	Hydraulic Hose 72"	2
10	HSV-1	1 Spool Hydraulic Valve	1
11	DB-LF-1	Lower Trailer Frame	1
12	DB-UF-1	Upper Trailer Frame	1
13	DB-SR-8	C-Style Snap Rings	12
14	LP-W-25	Washer ID 5/8 in	8
15	LP-N-25	Bolt 5/8x3/4in 20 TPI	8
16	LP-B-4	E-Style External Retaining Rings	1 Packages of 100
17	FG-6	Grease Fittings Assortment	1 Package of 110
18	DB-LFP-1	Lower Frame Pin 1"dim by 15" long	1
19	DB-UFP-1	Upper Frame Pin 1"dim by 9" long	1

APPENDIX E - BUDGET

Zachary Pate		Senior Project Buget							
Project Name:		Dump Bed Lifting Mechanism							
Item	Part #	Description	Source	ID #	Price	Quantity	Subtotal	Actual cost	Acquisition
1	DB-UA-T6-2	Raw Steel Tubes 2"x6"x36"	Online Metals	2x5x.25x60	$111.53	1	$121.57	$0.00	Donated
2	DB-LA-2	Raw Steel Plate, 5"x12"x.375"	Novak Farm	PS5X.375	$50.20	1	$54.72	$0.00	Donated
3	DB-LP-4	Pin material 1"x6' steel Rod	Western Metal	8920k231	$27.50	1	$29.98	$29.98	Purchased
4	DB-U-L-AB-10	DOM Tube 1.5"x.25x1"x6'	Online Metals	DOM1.5-25	$34.94	1	$43.73	$43.73	Purchased
5	LP-B-4	E-Style External Retaining Rings	Amazon	B000NB9G2Y	$5.95	1	$6.49	$6.49	Purchased
6	SR-8	C-Style Snap Rings	Hardware store	SR-8	$0.80	12	$9.67	$9.67	Purchased
7	LP-N-8	Bolt 5/8x3/4in 20 TPI	Fred Meyers	H02232392	$1.49	2	$3.11	$3.11	Purchased
8	LP-W-8	Washer ID 5/8 in	Fred Meyers	W02232	$1.49	2	$3.11	$3.11	Purchased
9	FG-6	Grease Fittings Assortment	Amazon	10035 SAE	$13.08	1	$14.26	$14.26	Purchased
10	HP-1	Hydraulic Pump 12 VDC	Surpluc Center	97384	$249.95	1	$272.45	$0.00	Donated
11	HC-1	Hydraulic Cylinder 2x6x1.125	Surpluc Center	9-8534-6	$58.95	1	$64.26	$0.00	Donated
12	HH-P-2	Hydraulic Hose 3/4"x24" NPTM	Surplus Center	9-078-24	$15.95	2	$33.34	$0.00	Donated
13	HH-C-2	Hydraulic Hose 1/2"x60" NPTM	Surplus Center	905-1260	$14.95	2	$31.25	$0.00	Donated
14	HSV-1	1 Spool Hydraulic Valve	Surplus Center	9-1262	$79.95	1	$87.15	$0.00	Donated
15	DB-MACH	Machining Cost	CWU	Time	$0.00	40	$0.00	$0.00	Work
							$775.06	$110.35	

APPENDIX F - SCHEDULE

PROJECT TITLE:	Dump Bed Lifting Mechanism																														
Principal Investigator:	Zachary Pate																														
		Duration																													
TASK:	Description	Est.	Actual	November				Dec		January				February				March				April				May				June	
				11/03/14	11/10/14	11/14/14	11/24/14	12/01/14	12/10/14	01/05/15	01/12/15	01/19/15	01/26/15	02/02/15	02/09/15	02/16/15	02/23/15	03/02/15	03/09/15	03/16/15	03/23/15	03/30/15	04/06/15	04/13/15	04/20/15	04/27/15	05/04/15	05/11/15	05/18/15	05/25/15	06/01/15
ID		(hrs)	(hrs)																												
1	Proposal*																														
1a	Outline	3.0	3.1																												
1b	Intro	2.0	4.0																												
1c	Methods	3.0	3.0																												
1d	Analysis	6.0	7.0																												
1e	Discussion	2.0	2.5																												
1f	Parts and Budget	3.0	3.2																												
1g	Drawings	5.0	7.0																												
1h	Schedule	1.0	3.4																												
1i	Summary & Appx	1.0	1.2																												
	subtotal:	26.0	34.4																												
2	Analyses																														
2a	Hydraulic OpenTime	1.0	1.0																												
2b	Force at Lift Point	2.0	1.0																												
2c	Statics	12.0	13.0																												
2d	Force of Cyliner	1.0	1.0																												
2e	Pin shear	2.0	3.0																												
2f	FEA	5.0	4.5																												
	subtotal:	23.0	23.5																												
3	Documentation																														
3a	Part 1 Lower Arm LA-1,2	2.0	2.0																												
3b	Part 2 Upper arm LU-1,2	3.0	2.0																												
3c	Part 3 Pin LP-1,2 UP-1,2	2.0	2.0																												
3d	Subassemly Sissor Lift	1.0	2.0																												
3i	Assemly	1.0	1.0																												
3j	Drawing	3.0	5.0																												
3l	ANSIY14.5 Compl	2.0	2.0																												
	subtotal:	14.0	16.0																												

4	Proposal Mods		
4a	Project DB Schedule	1.0	4.0
4b	Project DB Part Inv.	1.0	1.0
4c	Crit Des Review*	1.0	2.0
	subtotal:	3.0	7.0
7	Part Construction		
7a	Order Parts	4.0	3.0
7b	Part 1 LA-1	2.5	2.0
7c	Part 2 LA-2	2.5	2.0
7d	Part 3 Upper arm UA-1	6.0	4.0
7e	Part 4 Upper arm UA-2	5.0	3.5
7f	Part 5 LP-1	4.0	4.1
7g	Part 6 LP-2	3.0	2.3
7h	Part 8 UAB-6-1	2.0	1.7
7i	Part 9 UAB-6-2	1.5	0.7
7j	Part 10 UAB-6-3	1.5	0.7
7k	Part 11 UAB-6-4	1.5	0.7
7l	Part 12 UAB-6-5	1.5	0.7
7m	Part 13 UAB-6-6	1.5	0.7
7n	Part 14 LAB-4-2	1.0	1.2
7o	Part 15 LAB-4-4	1.0	1.0
7q	Part 16 DB-LF-1	10.0	8.0
7r	Part 17 DB-UF-2	7.0	1.8
7s	Part 18 DB-LFP-1	0.5	0.5
7t	Part 19 DB-UFP-1	0.5	0.5
7u	Take Part Pictures	1.5	0.2
7v	Update Website	1.0	0.2
7x	Manufacture Plan*	2.0	0.4
	subtotal:	57.0	39.9
	69.4		
9	Device Assembly		
9a	Assemble UA, UAB	4	6.5
9b	Assemble LA, LAB	2	5
9c	Assemble LP, LP, LA, UA	3.5	4.5
9d	Assemble cylinder to lift	2.0	0.5
9e	Frame Assembly	12	20
9f	Installing lift	1	4
9g	Take Dev Pictures	1.0	0.5
9h	Update Website	2.0	0.0
	subtotal:	21.5	29.5

10	Device Evaluation		
10a	List Parameters	5.0	2.0
10b	Design Test&Scope	4.0	2.0
10c	Obtain resources	3.0	3.0
10d	Make test sheets	3.0	1.0
10e	Plan analyses	5.0	2.0
10g	Test Plan*	5.0	4.0
10h	Perform Evaluation	3.0	4.0
10i	Take Testing Pics	2.0	1.5
10h	Update Website	2.0	1.0
	subtotal:	32.0	20.5
11	495 Deliverables		
11a	Get Report Guide	3.0	3.0
11b	Make Rep Outline	3.0	3.0
11c	Write Report	27.0	40.0
11d	Make Slide Outline	3.0	3.0
11e	Create Presentation	3.0	3.0
11f	Make CD Deliv. List	2.0	2.0
11e	Write 495 CD parts	2.0	2.0
11f	Update Website	3.0	2.0
11g	Project CD*	2.0	2.0
	subtotal:	48.0	60.0
	Total Est. Hours=	224.5	230.8 =Total Actual Hrs
Labor$	17	$3,817	$3,923
Note:	Deliverables*		
	Draft Proposal		
	Analyses Mod		
	Document Mods		
	Final Proposal		
	Part Construction		
	Device Construct		
	Device Evaluation		
	495 Deliverables		

APPENDIX G – EXPERTISE AND RESOURCES

Resources used were the CWU machine shop, and Novak Farm for assembly and testing. Expertise was given by Mr. Geoffrey Pate, mentor of the principal engineer.

APPENDIX H – EVALUATION SHEET

The following table displays the operation design requirement and will be recorded when the device is tested.

Design Requirement Load Test and Prediction Test.

Trial	Load	Angle	Time	PSI
Prediction	500 lb	40 degs	62 sec	1000
1	0	39	20	700
2	500	39	22	1200
3	500	39	19	1200
4	500	39	20	1200
5	500	39	21	1200

Table 1 Load, Angle, Time, and Pressure Testing Results

Angle Test

Trial	Angle
1	39
2	39
3	39

Table 2 Angle Testing

The following table displays size design requirement.

Size of the Device	Measured (Inches)	Required (Inches)
Length	24	26
Width	9	12
Height	14	16

Table 3 Device Size

APPENDIX I – TESTING REPORT

Objective: To collect data and analyze the performance of a dump bed lifting device to determine weight lifted, lifting time, and pressure required to lift load.

Test One

Introduction:

This test will be testing two design requirements. The first requirement is to measure the size of the device. The device will need to be under 26”x16”x12” The second test will test the angle of tilt the lift will be able to perform. The predicted angle is 40 degrees. These tests will be performed April 12, 2015.

Method:

The resources required for the test to be performed are a measuring tape, iPhone with angle measurement, three people, video camera, and a set up device.

Equipment:

Measuring tape.
Lifting device installed on a dump bed.
Hydraulic pump: None, keep ports to cylinder open.
iPhone with angle measuring app.

Procedure:

- First take a measuring tape and measure the dimension of device, and recoding X, Y, Z dimensions
- Next install scissor lift and open ports so air can go into the cylinder.
- Place iPhone on upper frame with angle app open and record initial value.
- Then lift up the upper frame to full height and record value.
- Subtract initial value with record value and that is the height.
- Repeat lift test and take an average.

Discussion/Conclusion

After completing the test the device was measured to be smaller than the design requirement dimensions. The device final angle was 39 degrees, this is one degree short of the design requirement. The 39 degree is still sufficient to dump the load, and passes the requirement.

Test Two

Introduction:

This test will be testing two design requirements. The first requirement is to measure the time the device takes to open. The predicted opening, dumping, and closing time is 62 seconds. The second test will perform a load test of 500 pounds. The predicted pressure to open the lift is 1000 PSI. These tests will be performed April 26, 2015.

Method:

The resources required for the test to be performed are a hydraulic system with pressure gage, iPhone with angle measurement app, three people, video camera, 500 pounds of concert, and working dump bed trailer.

Equipment:

500 pound of concrete, three 60 pound bags, and four 80 pound bags.
Lifting device installed on a dump bed trailer.
Hydraulic system: Connected to scissor lift.
iPhone with angle measuring app.

Procedures:

- Set up hydraulic system.
- Open lift and record pressure to open the bed.
- Then load concrete into bed and center it three feet back from the hinges so load is 500 pounds centered.
- Repeat procedure four more times.

Discussion/Conclusion

After testing the load requirement of 500 pounds the device was able to lift the load. The only issue was it took 1200 PSI to lift the load. This was due to a under calculation of the weight of the bed where 100 pounds was estimated where the bed weighted closer to 300 pounds witch required a extra 200 PSI to lift the bed.

APPENDIX J – TESTING DATA

Weight of Dirt Table

Number Bucket	Weight of Bucket
1	48
2	46
3	48
4	50
5	50
6	50
7	50
8	0
Total	342

Table 4 Five Gallon Bucket Weight

Volume of Five Gallon Bucket to Tractor Bucket

	1	2	Average
Weight of Five Gallon Bucket	50 pounds	50 pounds	50 pounds
Number of Buckets in Tractor Bucket	7	8	8

Table 5 Five Gallon Buckets to Tractor Bucket

Testing of the device.

Weight of Tractor Bucket	Number of Tractor Buckets Loaded	Weight in Dump Bed	Was Dump Successful
350 Lbs, 400 Lbs	2	750 Pounds	Yes
400 Lbs,400 Lbs	2	800 pounds	Yes

Table 6 Testing with Dirt

APPENDIX K - RESUME

ZACHARY PATE

zacharytpate@gmail.com
253.310.6186

EDUCATION

CENTRAL WASHINGTON UNIVERSITY January
2011 - June 2015
Ellensburg, Washington
BACHELOR OF SCIENCE; MECHANICAL ENGINEERING TECHNOLOGY

EXPERIENCE

EPIC AIRCRAFT June 2014 –
September 2014
Bend, Oregon
Materials and Process Engineer Intern

- Worked with a six member team of interns to establish a materials testing lab focusing on carbon fiber, fiberglass, and adhesives bonding for the certification of the E1000 airplane
- Worked with various instruments such as MTS, DMA, DSC, drill press, surface grinder, slow-speed-saw, vertical mill, and lathe to prepare and test specimens flowing ASTM standers
- Responsibilities included specimen preparation, dimensioning, material testing (SBS, CDP, DCB, Compression, Lap Shear, and Tensile Testing) data reduction, implementing new test plans, writing technical documents, laying up panels, specimen fixture development, machining, and welding
- Demonstrated the ability to learn quickly all aspects of testing process and to effectively execute them
- Individual projects included redesign of lap shear press, implementing hardness tester and DCB fixture and test plan into the testing process
- Designed and made drawings of fixtures to be sent out and built
- Specialized work with layup, surface prep, secondary bonding, composite bonding fracture analysis, determining failure modes, and parameters for acceptable or unacceptable failure modes (adhesive/cohesive/interlaminer)

DANICI ELECTRIC July 2007 –
September 2013
Breckenridge, Colorado

Apprentice Electrician

- Lead apprentice on both residential and commercial electrical projects to execute wiring, install breaker boxes and light fixtures
- Executed all phases of electrical project from rough to finishing work
- Demonstrated ability to learn quickly and effectively under journeymen and master electricians.
- Supervised and trained four new apprentices to further scale quality work

UNITED YOUTH CAMPS July 2012, July 2013
Tillamook, Oregon
Waterski Instructor

- Assisted teaching 100+ youth ages 11-19 how to water ski and wake board
- Lead safety monitoring for all youth and staff at waterskiing location with zero injuries
- Communicating effectively with staff and campers.
- Experience explaining waterskiing and wakeboarding techniques to campers while keeping them motivated.

THE DISPATCH September 2007 – June 2009
Eatonville, Washington
Sports Writer

- Self-managed writing of weekly articles covering community sporting affairs, including tennis and track
- Published articles under strict deadlines
- Electronic submission and peer editing

SKILLS

COMPUTER PROGRAMS

- SolidWorks -Certified Associate, Mastercam, Microsoft Word, Excel, PowerPoint, and AutoCAD, MSC-Pantran

DRAFTING

- For senior project I used SolidWorks to design 3D parts and assemblies, then export them to a 2D drawing so parts could be build according to drawing
- Experience with drawing to ANSY Y14 Standards
- Have had GD&T tolerance and drafting experience

MACHINING

- Vertical mill, lathe, 3 axis CNC mil, drill press, plasma table

BUSINESS

- Management, public speaking, reports

PROFESSIONAL SOCIETY

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, January 2011 – Present
Ellensburg, Washington
Officer, Vice President (2014-2015)

- Collaborated with other club officers to plan agenda and activities for club meetings
- 2014 Student Professional Development Conference (SPDC) poster competition competitor describing *Is Hydropower Worth It?*
- Club Treasurer from 2011-2014, managed, monitored and communicated club finances and spending
- Executed planning and financing of the 2012 Student Professional Development Conference at CWU

SOCIETY OF MANUFACTURING ENGINEERS January 2014 – Present
Ellensburg, Washington
Member, CWU Chapter Member (2014-2015)

- Participating in weekly club meetings
- Attends club facilities tour to SGL Composite, AGC Composites, Genie, GE Aviation, Pearson Packaging, Wagstaff, MacDonald-Miller
- Attended district conference on how SME can sever members

REFERENCES

Brock Strunk, Chief Structures Engineer	541.531.9552
Dave Goethals, High School Teacher	253.862.5565
David Novak, Danici Electric Owner	970.390.1173
Keith Tomes, Superintendent	559.631.5871
Mike Shide, Electrical Engineer	626.840.0450
Rex Sexton, UCG Camp Director	360.798.2921